TRANSACTIONS

OF

THE AMERICAN SOCIETY

OF

HEATING AND VENTILATING ENGINEERS

VOL. VII.

SEVENTH ANNUAL MEETING

NEW YORK, JANUARY 22-24

1901

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THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

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LXXVIII.

THE AMERICAN SOCIETY

OF

HEATING AND VENTILATING ENGINEERS.

SEVENTH ANNUAL MEETING.

New York City, January 22, 23, 24, 1901.

PROCEEDINGS.

First Session.

The Seventh Annual Meeting of the American Society of Heating and Ventilating Engineers was held in the hall of the American Society of Mechanical Engineers, No. 12 West Thirty-first Street, New York City, January 22, 23 and 24, 1901.

The meeting was called to order at 2.50 P.M., on Tuesday, January 22d, by Secretary Mackay.

Secretary Mackay: Gentlemen, in the absence of the president and vice-presidents, the Constitution provides that the meeting shall elect a temporary presiding officer from the members present, the secretary calling for the vote. I, therefore, request the meeting to elect a temporary chairman.

On motion, Mr. Stewart A. Jellett was unanimously elected as chairman of the meeting, *pro tem.*

The secretary called the roll, and a quorum being present, on motion the reading of the minutes was dispensed with.

The Chairman: The next thing on the programme is the president's address; but as the president is not here that will be necessarily postponed. I think it will be well to have it come in when he arrives.

Secretary Mackay read the following report :

REPORT OF THE SECRETARY.

New York, Jan. 22, 1901.

Gentlemen: Your secretary would report an increase in membership, and a better financial condition than last year. At the last annual meeting the society was composed of 111 members, one honorary member, seven associates, and three juniors, or a total of 122 members of all grades. Two members have been dropped from the rolls for non-payment of dues, two members have resigned, and we have just been informed of the sad and sudden death on the 19th inst., of Mr. Wm. McMannis, a charter member of, and an active worker in, our society. Twelve persons have been elected to membership, one to associate and one to junior membership, during the year, and one associate has been advanced to full membership. Our present membership is 119 members, one honorary member, seven associates, and four juniors, or a total membership of all grades of 131, an increase of nine over last year.

There was a balance in the hands of the treasurer of $33.01 at the last annual meeting, since when there has been received from all sources $1,327.07, making a total of $1,360.08, the total expenditures have been $1,274.15, leaving a balance in the hands of the treasurer of $85.93. There is a balance of $395 owing from the members for dues. The society owes $300 on last year's proceedings and $132.82 to the secretary, or a total indebtedness of $432.82, so that if all outstanding dues were paid, there would be a surplus of $48.11 on hand, in addition to which there was a loss of $60 to the society on the two members dropped from the rolls, so that the society may be said to be in a good financial condition, as compared with last year. The funds in the hands of the treasurer are divided as follows:

Hart Fund	$5.00
Dinner Fund	5.32
General Fund	75.61
Total	$85.93

The secretary's expenses for the year, including stenographer, clerk hire, postage, rent of P. O. box, expenses in

connection with exhibit at Paris Exposition, expressage, etc. amounted to $304.73.

The annual proceedings for 1900 are in the printer's hands, and will be forwarded to the members during February.

The proceedings of the society are sent free to thirty-two of the leading colleges, engineering and architectural societies.

Through the influence of Mr. Wiltsie F. Wolfe, the American Commissioners to the Paris Exposition agreed to make such an exhibit as we might send, free of cost. Two complete sets of our proceedings and some photographs of school-heating apparatus forwarded by Mr. T. J. Waters, a member of our society and chief engineer of the Chicago Board of Education, were forwarded and we were awarded a bronze medal on our proceedings and honorable mention on the school heating photographs.

W. M. MACKAY, Secretary.

The secretary then read the report of the Board of Governors, as follows :

REPORT OF THE BOARD OF GOVERNORS.

Annual Meeting, 1901.

Gentlemen: Your Board of Governors organized January 25, 1900, and in addition to appointing committees from among its members on Finance, Membership and Publication, they elected an Executive Committee, composed of New York City members, so that the affairs of the society would not suffer through the absence of, or inability to attend the meetings of the Board by, any of its members.

The various committees have given careful attention to their duties, the Board has held meetings during the year, when necessary, and as a result we are able to report the society in a better position financially and in point of members than a year ago.

There is still considerable money owing the society from members, for dues, most of it being for 1900, and we would urge upon the members the necessity of a prompt payment, so as to enable the officers to best further the interests of the society.

SOCIETY EXHIBIT,
PARIS EXPOSITION,
1900.

AWARD:

BRONZE MEDAL
ON PROCEEDINGS.

HONORABLE
MENTION
ON SCHOOL PLANS
OF GEORGE DEWEY
SCHOOL,
CHICAGO, ILL.

PRESENTED BY
T. J. WATERS,
CHIEF ENGINEER
BOARD OF
EDUCATION,
CHICAGO, ILL.

The papers for presentation at this meeting were received too late, to give an opportunity to forward them to the members in time to allow them to prepare a discussion on them. We have also been disappointed on account of press of business and sickness on the part of some of the members and others who had promised papers for this meeting, but who were unable to complete them. We would suggest that members who contemplate furnishing papers for future meetings endeavor to complete them a month to six weeks before the date of the meeting, so as to give ample time for editing, the preparation of cuts, printing and distributing and the preparation of discussion. Such an opportunity would increase the value of the paper, and make the meeting more interesting.

The society voted to dispense with the summer meeting last year, and consequently none was held. It would be well to consider the subject again at this meeting.

On motion, the report was received and filed.

The report of the treasurer was then presented, as follows:

REPORT OF THE TREASURER.

New York, Jan. 22, 1901.

Balance on hand Jan. 23, 1900		$33 01	
Cash received since Jan. 23, 1900:			
Dues	$1,170 82		
Initiation fees	115 00		
Proceedings	40 09		
Pin badge	1 25	1,327 07	
			$1,360 08
Disbursements for the society:			
Secy., 1899 account		$58 00	
W. N. Jennings, bal. 1898 proceedings		315 83	
Account editing and printing 1899 proceedings		235 81	
Secretary's account		171 94	
Mechanical Engineers' rooms		65 00	
Stenographer (annual mtg., 1900)		154 00	
Papers, 1900 meeting		41 25	
Cuts, 1900 meeting		86 50	
Carried forward		$1,128 33	

Brought forward	$1,128 33	$1,360 08	
Dinner Committee	10 25		
Members' ballot, June	10 50		
Members' ballot, January	11 00		
Treasurer's bond	15 00		
Certificates of membership	6 00		
Sundry accounts, printing, stationery, etc.	93 07	1,274 15	
Balance in Washington Trust Co		$85 93	

Respectfully submitted,

JUDSON A. GOODRICH, Treasurer.

The Chairman: The next is the report of the Committee on Uniform Contract and Specification, John Gormly, chairman. Mr. Barron of that committee is here, and Mr. Chew. Mr. Gormly, I believe, cannot be present.

Mr. Chew: I talked with Mr. Gormly between Christmas and New Year's on this subject, and he thought that the only thing that could be reported was progress; that he had been doing some work, and that the report printed in our proceedings a year or two ago really was the condition now, except that progress was made, and nothing could be done at the present time to further the object in view.

The Chairman: The committee reports progress. The next report is that of the Committee on Standards, Prof. J. H. Kinealy, chairman.

Professor Kinealy: Mr. President and members, I take great pleasure in being able to report for the Committee on Standards, that we have done during this past year a great deal of work. We have devoted almost our entire time to one subject; namely, the drawing up of a code for testing direct-radiation heating plants, to determine their efficiencies. We have devoted all of our time to this to the exclusion of some other matters, which were referred by special vote of the society to this committee at the last meeting. We have done this because we considered that this code was of special importance, not only to the members of the society, but to all who are engaged in any way in heating work. I will now read the code which the committee has drawn up.

Professor Kinealy then read the report.

The Chairman: Gentlemen, you have heard the report of the Committee on Standards, which I consider a very interesting one. It covers a subject on which we all want information. I had a suggestion to make as I heard it read, and I shall ask our secretary if it is possible to carry it out. That suggestion was that we get it to the printer at once, and see if he cannot have proof copies of it ready for us by Thursday's meeting, so that the matter could be then generally discussed, and additional information brought out. I think it is the kind of report that ought not to wait a year for our proceedings. It is information that our members should have, and if that suggestion meets with the approval of the members, I think it is possible to get the printer to push these things through for us possibly by tomorrow night. If he can, all the better.

Mr. McKiever: I move that the report be received and the secretary ordered to have it printed at once. (Carried.)

The Chairman: The next report is the report of the Committee on Tests, Mr. A. A. Cary, chairman.

Mr. Cary: Mr. Chairman and gentlemen, the Committee on Tests, I am sorry to say, has very little to report. There has been no money at our disposal for work, which we might take upon ourselves. There have been no suggestions and no communications from any of the members of the society, and in consequence we have had no material and no funds, and we have nothing to report at this meeting.

The Chairman: The next is the report of special committees. The secretary tells me that the only committee is the Committee to arrange with the American Institute of Architects, on the question of professional fees. As I am chairman of that committee, I will ask Mr. Kent to take the chair while I read that report.

Mr. Kent took the chair.

Mr. Jellett then read the following report:

REPORT OF COMMITTEE TO ARRANGE WITH THE AMERICAN INSTITUTE OF ARCHITECTS, ON THE QUESTION OF PROFESSIONAL FEES.

Your committee report that, following the instructions given at the last annual meeting, the matter of the adjustment of professional fees was taken up with the committee appointed

by the American Institute of Architects to confer with our committee, this committee consisting of Mr. A. J. Boyden, of Philadelphia, chairman, Mr. Cook of New York City, and Mr. Hill of Washington, D. C. Your committee have had considerable correspondence with the committee of the Institute of Architects on the matter, and the chairman of the Institute of Architects' committee and our committee have held several meetings to discuss details. As a result of this correspondence and the meetings held, the committee of the American Institute of Architects submitted to their annual meeting, held in December, 1900, in Washington, D. C., the following resolution:

"We recommend that the schedule of charges of the Institute be so amended that the minimum charge for professional services in connection with electrical, mechanical, and sanitary engineering, heating and ventilating, shall be 10 per cent. on the cost of these portions of the work, the architect to select or approve any experts required, and to assume all expense for their services, whether rendered by members of his personal staff or engaged for a specific work."

After considerable discussion at the general meeting of the Institute of Architects, a resolution was passed, referring the matter to the incoming board of directors, with the favorable recommendation of the institute and with instructions to have the schedule of charges, which is part of the by-laws of the institute, amended to include the recommendations of the committee. This was done in order that the proper wording should be used, and that the schedule as amended would be clearly understood. The board of directors of the institute still have the matter under consideration, as the following letter from Mr. Glenn Brown, the secretary of the institute, bearing date of January 18, 1901, will show:

"WASHINGTON, D. C., January 18, 1901.

"Mr. S. A. Jellett, Chairman, Society of Heating and Ventilating Engineers, Philadelphia, Pa.

"Dear Sir: The subject was referred to the Executive Committee, and they did not think it could be disposed of hastily, and still have it under consideration.

"Yours very truly,

(Signed) "GLENN BROWN,

"Secretary, A. I. A."

The chairman of your committee has also conferred with a member of the board of directors of the Institute of Architects who strongly favors the matter, and this director has stated that the matter will be taken up promptly, and the question settled, as he thinks it is of the utmost importance that some action should be taken.

Your committee feel that, as this matter is of far-reaching importance, a material advance has been made during the past year, and we would recommend that a resolution be passed at this meeting, instructing the Board of Governors that when definite action has been taken by the American Institute of Architects, and the revised schedule of charges published covering professional fees, they, the Board of Governors, shall, in their discretion, indorse and uphold such action; and that the Board of Governors be directed to notify the members of our society.

STEWART A. JELLETT, Chairman.
R. C. CARPENTER.
HENRY ADAMS.

Vice-President Kenrick took the chair.

The Chairman: What action will you take in regard to the report just made by Mr. Jellett, of Philadelphia?

Mr. Jellett: I might add by way of explanation that the Institute of Architects' schedule of professional charges is a part of their by-laws, and covers the making of sketches, the making of plans and specifications without superintendence, and the completed work. That is the reason for referring the matter to the board of directors, so that it can be properly classified. The intention is, that upon action by the board of directors a new schedule of charges shall be issued, and go into effect within a short time. After the issuance of this new schedule the architect shall receive for all buildings in which there are mechanical plants a full engineer's commission, and his own commission for the mechanical work. The bone of contention all along has been that the architects object to taking their commission on a large portion of the work and handing it over to an engineer; and yet, at the same time, they could not carry on the work themselves. The matter was discussed in all its phases with their committee, and they recognized the fairness

of the proposition made by our committee, that architects should not ask contractors to make plans and specifications for nothing, and that they in turn should not be asked to study in the owner's interest, the details of mechanical plants, so as to save him money, entirely at their own expense. So that if a building now costs $100,000, and the mechanical plant costs $10,000, the architect expects to get 10 per cent. on that portion of it, and be prepared to pay full commission to the engineer for the portion which he is called on to plan. I think this is entirely fair, and it seems to meet the approval of architects all over the United States. The committee of the Institute of Architects expected some pretty open opposition in their meeting from several architects who had engineers in their employ. They expected strong opposition from those sources; but it did not come. The reports that I got from members of the institute who were present, were to the effect that it was the feeling of all that the additional labor involved in the mechanical plant of a modern building was worth the additional outlay, and that they would indorse the recommendation, and when action is finally taken (our society having started the question), we must stand back of the architects in this matter.

Mr. Cary: I make a motion that the report be received and the committee continued.

The motion was seconded by Mr. Paul and carried.

The Chairman: The report has been received, and is now before you for discussion.

Mr. Kent: I move the adoption of the resolution contained in the report. (Carried.)

The Chairman: Are there any other reports under the eighth order of business? If not, the next in order is the appointment of tellers, and I appoint at this time as tellers to count, sort, and declare the votes cast for the officers, Mr. B. H. Carpenter, of Wilkesbarre; Mr. A. A. Cary, of New York; and Mr. J. A. Connolly, of New York.

The next order of business, gentlemen, is new business.

Mr. McKiever: I think it would be very proper at this time to send to the family of our late member, Mr. McMannis, resolutions of regret at his untimely end, and with that in view, I would move you, sir, that our secretary be instructed to communicate with the family of the late Mr. McMannis, expressing

our sincere regrets, and that a committee be appointed to draw up suitable resolutions.

The Chairman: It is moved and seconded that a committee be appointed to draw up a set of resolutions to be sent to the family of our deceased member.

The motion was carried.

The Chairman: Gentlemen, I would like to take a few minutes to think that committee over, and will report later this evening. Is there anything further under the head of new business?

Professor Kinealy: I want to say something, and it should be in the nature of new business—I don't know that I am prepared to make a motion about it; but it is in regard to these standing committees. I think I can say this with a good deal of appropriateness, because I am chairman of a standing committee. As a matter of fact, I do not think standing committees are good things, and I should like very much to see these standing committees discharged, and all the standing committees struck off, and when anything is to be done, let that thing be referred to a special committee. I think we would get better work. I should like very much to know what the other members think about it. I have talked to some about it, but I am not yet ready to make a motion. I am willing to make a motion to discharge myself. (Laughter.)

The Chairman: Gentlemen, you hear the suggestion as offered by Professor Kinealy.

Mr. Kent: I am generally on the opposite side of anything Professor Kinealy has to offer. I would like to have the Committee on Tests abolished, of which committee I happen to be a member. We are no good; nobody wants any tests made, we do not want to make them, and we have no funds. But there is one committee that ought to be continued for all time —the next fifty years at least—the Committee on Compulsory Legislation. I hope that will not be wiped out.

Mr. Cary: As chairman of another standing committee, I quite indorse Professor Kinealy's expression on that subject, and I will take Mr. Kent's amendment if we consider it so. I think that the Committee on Compulsory Legislation should be continued, and all others should be wiped out, as Professor Kinealy suggests.

Mr. Jellett: Are not those committees required by our Constitution and By-Laws? We cannot wipe them out so fast, if that is the case.

Professor Kinealy: No; but we can begin.

Mr. Connolly: I heartily indorse what Professor Kinealy and Mr. Kent and Mr. Cary have stated, and I am more strongly of that opinion since I heard read Professor Kinealy's report from the Committee on Standards. I think the committees should all be abolished, and I move that they be abolished, and that special committees be appointed when necessary. (Seconded by Professor Kinealy.)

The Chairman: Do you include the Committee on Compulsory Legislation?

Mr. Connolly: I do. I think a special committee could take care of that as well as any one else—perhaps better, because legislation changes in New York State.

The Chairman: The motion is made by Mr. Connolly and seconded by Professor Kinealy to abolish the committees, the several committees named in our programme here. That question is before the house for discussion. I will say that the Committee on Compulsory Legislation consists of Henry Adams, chairman, T. B. Cryer, A. Harvey, T. J. Waters, and B. H. Carpenter. On Uniform Contract and Specification, John Gormly, chairman, H. J. Barron, A. E. Kenrick, R. P. Bolton, and Frank K. Chew, compose the committee. The Committee on Standards consists of Prof. J. H. Kinealy, chairman, Herman Eisert, H. A. Joslin, William McMannis, and J. J Blackmore. The Committee on Tests consists of A. A. Cary, chairman, William Kent, C. M. Wilkes, James Mackay, and B. F. Stangland.

Mr. McKiever: I would offer an amendment that the duties of the same committees be continued, but that the committees be appointed by the incoming Board of Governors. My idea is this, that I think the committees can do some good, and I think the proof of it is the reports that have been handed in by two of the committees. Of course, the third committee reported that they had no report to hand in on account of having no money to make tests. I think the nature of their report should be a comment on tests made by other engineers; that would give them a chance to hand in a report which would be of great

service to us, without any expense to the society at all, and all those committees should be continued I think. I think they can accomplish a great deal of good work if they attend faithfully to their business.

Mr. Connolly: In answer to that I would state that after seven years of this, I do not think anything at all has been accomplished. A member suggests that a special committee could do more effective work; I heartily agree with him on that. If we are not to get results in seven years when are we going to get them?

Mr. Jellett: Mr. Chairman, I hardly think that last criticism is fair. The gentleman has evidently not been on the committees or done any of the work, or he would not make that statement. Now, there has been a good deal of work done by the committees. There has not been the work done that we all hoped would be done, but you must recall one thing, and that is, that the majority of men, in fact, all the men in this society that I know, are busy men. They cannot drop their business to take up committee reports. What they do is done out of business hours, and there has been a good deal of it done. Take the Committee on Compulsory Legislation (I am not a member of that committee now, I was formerly); I know that members of that committee appeared before the legislatures in different States and urged the passage of an act. I have appeared myself at different times before a committee of the Legislature in Pennsylvania. I have framed a bill for the Legislature at Harrisburg. It got as far as the second reading and was defeated, but it does not follow that there was not good work done, and I was told by the State Board of Health to continue it, and that we would eventually get such a bill through. The same work has been done in the legislatures of New Jersey and Connecticut, and the State of New York, by the special efforts of members of this society. I do not think because we have not the law in effect in those four States that it should be said that we have not had good work done. It is a mistake; we have had good work done. The same is true of the report of the Committee on Standards to-day. It gives information that no one has time to figure out in his own business. Take the committee that I happen to be chairman of now, to arrange with the architects regarding engineer-

ing charges. It is a big question to change the prevailing custom of charging for work in a profession where it has been standing for thirty years without any change, and you cannot do those things over night, and you cannot do them without concerted and systematic effort, and you cannot expect to do it all in a week or a day. I think it is a mistake to say that standing committees do no good. I will grant you that sometimes when a subject comes up a special committee of men interested in that particular branch might be found who have more leisure time than some other members, that is, at the date of their appointment they might have leisure time, but at the date when the work is to be done they might be the busiest men in the organization. So I do not think the special committee gains anything over a standing committee.

Mr. Kent: Since I have heard the names of these men who are on the standing committees, I do not think better men could be selected in this society on any special committee, for their particular work. Merely changing the name of a committee from standing committee to special committee is not going to push the work any further. Mr. Jellet will not do any better work in regard to compulsory legislation if this committee is discharged, and a new committee called a special committee made up. The committee is as well constituted to-day as it possibly could be. In respect to the Committee on Uniform Contract and Specification, I understand the only reason we have not a report here to-day is because Mr. Gormly is sick. It would not be very courteous to Mr. Gormly to discharge him when he is sick. With regard to the Committee on Standards, that committee has presented a report, and we are ready to discuss it as soon as it is printed, and I do not think it would be courteous to discharge them. The only committee that might be discharged is the Committee on Tests, but I will say that if any one has testing to be done, if any one has any tests to discuss, or anything to propose, I do not think you could get any members of the society better qualified than Mr. Cary, Mr. Wilkes, Mr. Mackay, Mr. Stangland, and myself for that purpose, and we would be glad to do it. But no one has wanted any tests made, and no one has reported to us, and we are not going around hunting for tests for the purpose of getting a report. I have no objection to letting the names

stand for the next five years as the Committee on Tests, and do nothing, but I am not willing to have these other three committees discharged.

Mr. Cary: I indorse what Mr. Kent says, we both being on the same committee, but I must take exception to the remarks of the gentleman who criticised us rather severely a little while ago. He proposes that we should go around the country and gather up all the tests that we can get. Ninety-nine hundredths of those tests are not worth the paper they are written on. If we should gather them together and try to draw deductions from them, I am afraid we should have a very poor lot of stuff to put before you. As Mr. Kent has said, if there is anything brought up by the society and referred to the Committee on Tests, we are ready to take hold of it, but we have not had such matters referred to us, and we have had no funds put at our disposal to go on with special testing of our own selection, so we are in rather an unfortunate position, but I think this may be the case for some time to come, and may be it would be better to keep the other committees and to excuse the Committee on Tests.

Mr. B. H. Carpenter: As a member of the Compulsory Legislation Committee, I do not know what our chairman has to report, as he is not here, but it is a slow matter, and it is a difficult matter. In the State of Pennsylvania there has been nothing that I know of done this year. In the first place, there is a bill before the Legislature, as Mr. Jellett has said, and it is in good hands. The Legislature meets every two years; it is in session now, and the party that has the bill in hand to push it forward, wrote me a letter the other day, saying that the State superintendent is down on record as saying that the schools and public buildings, so far as he knows, need no further legislation of any kind; everything is in good shape. That simply ties everything up. It is no use trying this year.

Mr. Kent: I have a report to make to the Committee on Compulsory Legislation, about the State of New Jersey. I was at the meeting of the New Jersey Sanitary Association, at Lakewood, a couple of months ago. It is a voluntary association, which can be joined by any one who has any interest whatever in sanitary matters. Some one was talking about Massachusetts, and how far Massachusetts is ahead of other

States. I said: "I believe Massachusetts is the only State in the United States that has a law for the ventilation of its public schools," and the chairman of the Association said: "You are mistaken, sir; New Jersey also has one." I said: "I am surprised to hear that. I knew they were trying to get one." "Yes," he said, "they passed one last month." I have since been informed that that man was mistaken. Now, there was the New Jersey Sanitary Association, and no one there seemed to know whether there was any law in New Jersey as to the ventilation of public schools, and I believe the president of that association made a mistake in saying that there was such a law.

Mr. Jellett: There has been such a bill introduced there and advanced to a second reading some time ago. Those things are all put down on the calendar towards the tail end, until there is sufficient energy back of them to push them through.

Mr. Andrus: There is a pretty good ventilation bill before the Legislature of the State of New York now, and I think it is in pretty good hands, and I think it will probably go through, although it does not emanate from this society.

Secretary Mackay: I would state that this bill that the society presented some two years ago has been taken up and presented by a member of the Legislature from New York City, and by a senator from Westchester County, I believe, who propose to to see it through, and I might say that that member of the Legislature is chairman of the particular committee that it would be referred to, so that we have every hope that it will become a law, and if it does, it will be largely through the efforts of this society. That is, the wording of the bill came from this society originally, and the bill before the Legislature is merely a copy of it.

Professor Kinealy: My objection to a standing committee is that the work of a standing committee is too broad. A standing committee must cover too much ground. The secret of success in life, in business, in any business we have to do, is concentration. If there is any hope of passing a bill for compulsory ventilation of schools in New York, let us have a committee from this society to attend to the State of New York. If here is any hope of passing one in New Jersey, let us have a committee to attend to New Jersey, and so on. The same way

with tests. We have a Committee on Tests. What do we test? What ought we to test? Buildings and radiators and fans and indirect systems of all kinds, and hot-blast apparatus? The ground is too broad. Let us have a committee on hot-blast apparatus, a committee on fans, if necessary. Let us have special committees, and let three or four or five men concentrate their energies on this one special thing for one year, and at the end of seven years or ten years we will be farther ahead than if we had the same number of men on a committee covering the whole creation. That is my objection to standing committees. The same way with the Committee on Standards; there are too many things to think about, too many things to do. As a result, the committees do not do as much as they would if the same men were concentrated on one thing.

Mr. Kent: I do not understand Professor Kinealy's statement at all. If there is anything that this Committee on Compulsory Legislation has done in the past it has been to concentrate itself on the New York Legislature. As I understand the report from Professor Kinealy himself, his Committee on Standards did concentrate itself on that one particular case on which he reported, and this Committee on Tests is willing to concentrate itself on air valves or anything you will give it to test. I do not see any point whatever in this question of things being too broad. The committees that have worked have in nearly every case concentrated their ideas on certain definite things.

Mr. Jellett: There is a great deal of force in what Professor Kinealy says in relation to the Committee on Compulsory Legislation—a commitee from the State of New York, rather than a committee scattered all over creation, to go before the New York Legislature. A committee of our members from one particular State to handle a matter before the legislature of that particular State ought to do better work than a general committee, and who cannot reach one another except by correspondence. There is a great deal of force in that, particularly in respect to the Committee on Legislation. It is a side of it I had not thought of before. If we had members enough in any one State, we might pick a good working committee, let them take their own representatives, and they will get a hearing

where a man from another State would get a hearing, because the home committee might influence votes, and votes are what the legislators are looking for. The difficulty with a problem of this kind is that to enforce compulsory legislation requires spending money. The farmers always oppose that. They say they get all the ventilation they want around the country. I have run across that time and again with different committees. I have run across it with county commissioners, in the matter of ventilation of court houses and buildings of that kind. I had to do with one court house a few years ago, where the county commissioners said: "We want to ventilate the court-room." I said, "You mean the court house." They said: "We don't mean anything of the kind. We mean the court-room. The judge is a power in this county, and insists upon having ventilation. So we want the court-room ventilated. The rest of the building we don't care anything about." I believe that Professor Kinealy's suggestion with regard to that particular committee is a very good one. I think the whole matter should be carefully thought over. I do not think it is wise to reach a conclusion just now on that subject. I think we ought to have a fuller meeting, that we ought to have more time to think over the ultimate results that will come from a change of this kind.

Mr. Barron: Have the standing committees done work here since the society first organized? They have done a little, but I think special committees would have accomplished more. A special committee for this purpose, appointed at each meeting, I believe, will accomplish more than a standing committee.

Professor Kinealy: Now, in regard to the Committee on Standards, the present committee made a report. The present committee simply resolved itself into a committee on a standard code. That is what we did, and as I state in my report, we neglected things that were specifically by vote of the society referred to us to do. We did that.

Mr. Kent: A special committee would do the same.

Professor Kinealy: A special committee would not have done the same, because the things that have been referred to the standing committee would have been referred to a special committee, and not to a committee on code. I think that is what it would be all the time. In other words, the same number

of men that are on this Committee on Standards, could be made up into two committees, and instead of having five engaged on this one thing, you would have perhaps two, and the other two or the other three would be engaged on the other thing. I think we would get more work done.

Mr. Cary: Mr. Chairman, I question very much whether we would have had a report on code for testing brought before us to-day if we had waited for the society to present this to some special committee. The committee that has been formed has selected work which seemed to be pressing, and in consequence we have got this report on codes. I do not think if we had been working on the other lines, we would have had this report on codes before us, which is most important.

The Chairman: Do any other gentlemen wish to be heard on this subject? If not, I will put the motion. The motion as I understand it, made by Mr. Connolly, of New York, and seconded by Professor Kinealy, of St. Louis, is that we dispense with our standing committees as made up.

Mr. Kent: I move that the question be referred to the Board of Governors, with instructions to report at the final session of this meeting. (Carried.)

The Chairman: Gentlemen, I understand that the secretary at this time is prepared to give us a list of some members.

Secretary Mackay announced the following additions to the list of membership: Theodore H. Hinchman, Jr., William C. Bryant, John J. Harris, Daniel Ashworth, Charles H. Davis, Alvin D. Reed, William Robert Maguire, Henry H. Jennins.

On motion the session adjourned to 8 P.M.

SECOND SESSION.

The meeting was called to order at 8.45 P.M., on Tuesday, January 22d, Vice-President Kenrick in the chair.

The Chairman: The meeting will please come to order. I will now name the Committee on Resolutions on the death of Mr. McMannis: C. B. J. Snyder, Andrew Harvey, J. A. Connolly, N. P. Andrews, and William H. McKiever.

The next business in order is the report of the tellers.

Mr. Cary read the tellers' report as follows:

REPORT OF TELLERS.

New York, Jan. 22, 1901.

Gentlemen: We, the undersigned tellers, respectfully report the following result of election by ballot for officers:

Total number of votes cast, 79, one of which was irregular.

For President:	J. H. Kinealy	50
	A. E. Kenrick	28
For 1st Vice-President:	Wm. McMannis	57
	Wm. H. Bryan	18
	John D. Hibbard	1
For 2d Vice-President:	Andrew Harvey	57
	Geo. Mehring	20
For Secretary:	Wm. M. Mackay	67
	Wm. H. McKiever	11
For Treasurer:	J. A. Goodrich	65
	Henry L. Hall	10
For Board of Governors:	R. C. Carpenter	70
	W. Kent	50
	Reginald P. Bolton	46
	John Gormly	60
	C. B. J. Snyder	42
	J. J. Blackmore	30
	Geo. I. Rockwood	22
	Herman Eisert	22
	Benj. W. Wilson	10
	B. F. Stangland	25

By this ballot it will be seen that the following are elected:
President, J. H. Kinealy.
1st Vice-President, Wm. McMannis.
2d Vice-President, Andrew Harvey.
Secretary, Wm. M. Mackay.
Treasurer, J. A. Goodrich.
Board of Governors, R. C. Carpenter, W. Kent, R. P. Bolton, John Gormly, C. B. J. Snyder.

Respectfully submitted,

JNO. A. CONNOLLY.
B. H. CARPENTER.
ALBERT A. CARY.

The Chairman: Gentlemen, you have heard the report of your tellers for the election of officers for the ensuing year. Is there anything to be said at this time?

Mr. Jellett: Mr. President, the question of the election of a vice-president, of course, will have to be taken up and settled, as we all regret very much to hear this afternoon of the death of Mr. McMannis, and from the report of the tellers, it seems that Mr. McMannis had the largest number of votes for the office of first vice-president. Of course, his death prior to this meeting, renders this election of no effect. There is no election, and under our Constitution and By-Laws there is only one way that I can see to proceed, and that is that there shall be candidates selected again for this office, and a letter ballot sent out for votes in the manner directed by the Constitution and By-Laws. From the one clause in the Constitution and By-Laws affecting it, it seems to me very clear that the duties of the Board of Governors are limited to filling vacancies between the annual meetings. The wording is very clear: "Whenever, by resignation or otherwise there shall be a vacancy in any office between the dates of the annual meetings, the Board of Governors shall have the power to fill such office for the balance of the term," This vacancy occurs at the annual meeting, and not between meetings, and therefore there can be no election of a vice-president as I interpret the Constitution, and there is only one method provided for election to office in this society, and that is by letter ballot. We cannot act here, because the members here are a minority of the membership, and we cannot take away from those not present their right to vote for an officer. I think it is a matter that wants to be settled now and settled right, because it is something that might happen at other times, and whatever we do ought to be done after giving the subject careful consideration and thought. I think that it is clear that that is the only way under our Constitution in which the matter can be settled. There is one clause that some members seem to think might conflict with this, and that is under the duties of the Board of Governors where there is a general outline given as to what their duties are, and among those it states that they shall fill any vacancy occurring among the officers of the society. But a Board of Governors or Managers or any officers of that kind naturally fall away when the body itself

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is assembled in general meeting. That is to say, the assemblage of the body of members of a society is paramount in power to any of the officers. The terms of the present Board of Governors will expire with this meeting. They have no right under parliamentary law to elect their successors or to elect an officer to an important position. The new Board of Governors to come in would not have that right until after the adjournment of this meeting. If the vacancy had occurred at that time they would have that right, but they have no such right under our Constitution at the present time. I therefore move that the chair either appoint a Nominating Committee, or that the old Nominating Committee take hold and nominate new candidates for this office, and that a letter ballot be sent out in the usual way provided by the Constitution. (Seconded by Mr. Cary.)

Mr. Harvey: Mr. Chairman, I would just like to ask for information. In all other societies, and in almost all cases where a person holds office, is it not supposed that the person in office will hold that office until a new incumbent is elected or appointed? In that case would it not be in line for the present first vice-president to hold the office until another one is duly elected in the proper manner.

The Chairman: In answer to Mr. Harvey, perhaps I am placed in somewhat of a delicate position, but I will say perhaps it may be an unwritten law that the old officer retains his position until the new officer is elected and installed in office. That has been the practice where I am, although it is rather a delicate matter for me to so decide.

Mr. Harvey: I did not think of the present vice-president being here.

Mr. Jellett: Mr. Chairman, that is correct. I agree with you on that interpretation, and in any case it takes thirty days under our rules to elect. The question that puzzled me, and I studied it considerably the last ten minutes, as some of you know, is what the proper method of procedure is. The rules distinctly define that there shall be elections at our annual meeting. Therefore it limits the terms of officers to one year by that fact. They appoint a committee to nominate officers for the ensuing year. This has been done. The ballots were sent out, and before they are all received there is the death of one candidate, and we cannot determine what is to be done until after

the ballot itself is announced. This comes at the annual meeting. Now, the society at its annual meeting has the power in its own hands entirely, to proceed to elect a candidate to fill the place, or to allow the election to fall, interpreting it as no election and continue the present officer, or to nominate other candidates and elect them in the usual manner. There are three ways to look at it. The only reason I bring the matter up now for consideration is that whatever way we decide is the proper way will be a precedent in this society. It never has arisen in this way before. At the time when Mr. Hart, our secretary, died, we had no Constitution and By-Laws. We had a set of general rules that gave no power to any Board of Managers or other officers outside of the meeting itself practically, so that what was done then was no precedent. The Board of Managers elected a successor to Mr. Hart after the meeting. But what we do here now will establish a precedent in this society, and whatever is the better way is what we want to take. Personally, I would rather see some way of settling it right here at the meeting, than going out and taking thirty days for a letter ballot. But we are a minority of the members of the society, and we cannot take away from the men who voted for Mr. McMannis their right to vote for somebody else, as I understand it. There are fifty-eight members out of ninety that voted for Mr. McMannis for vice-president. We cannot say who will be their choice, and it is rather a nice point. We cannot assume to ourselves the right here to elect a man to take his place, without giving the other members of the society an opportunity to vote; because the idea of a letter ballot was that all members should have a vote in electing the officers of this society—not that the meeting should elect, and we are going away from the spirit of the letter ballot if we ignore that, I think.

Mr. Connolly: I would like to add a point of information. I would like to ask Mr. Jellett, through the chair, if there is anything in the By-Laws in the event of the first vice-president dying, which has now happened—is there anything in the By-Laws about the second vice-president being moved up to the place of first vice-president?

Mr. Jellett: No. There is nothing of that kind in the Constitution. It is not customary where there is a letter ballot,

to have a man who is elected to one office assume a higher one. That is not customary as I understand it. There has been no election of Mr. McMannis. That is the one point we want to keep clear. The election of a man requires that he should not only have a majority of the votes, but that he should accept the office, in order to complete the operation. Now, Mr. McMannis's death prior to the reading of this ballot prohibits there being an election. There is no election.

Mr. Kent: We have with us as guest here to-night Mr. James C. Bayles, who ought to be known to heating and ventilating engineers, as past president of the Board of Health of New York City, an author of a book on drainage and other things, and he has had experience in this line, and I would like to ask for him the privilege of the floor, so that he can say something on this subject.

The Chairman: If there is no objection to the gentleman making any remarks on the subject, the chair offers him the privilege of the floor.

Mr. Bayles: Mr. Chairman, I am complimented by the invitation. I had some experience touching this very point in my own case. I was candidate, by accident, for the presidency of a society, and I received more votes than the man who was elected, but I was not eligible for that office, having served two consecutive terms, and being constitutionally debarred from a third consecutive term. Consequently my ballot could not count, and the next highest in line took office, by virtue of the fact of being the recipient of the next largest number of votes cast. In a case of this kind I think, as a matter of constitutional law, it would appear that no vote was cast at all for this gentleman, because his unfortunate death anterior to the announcement of the ballot makes it as if it were cast for John Smith, and there is no John Smith in the society. Consequently, the original vacancy exists, and the gentleman chosen by the largest number of ballots is undoubtedly, as a matter of constitutional law, the choice of the society by letter ballot as first vice-president.

Mr. Jellett: I was thinking on the same line as Mr. Bayles, that the man receiving the second vote was declared elected. But there is a very distinct difference here between the cases cited. In one case the candidate was debarred by their own

rules from being a candidate. It was an error in a nomination. There is no error in this nomination at all, and I doubt if that would apply in this case, because we have got, as I said before, a decided majority in favor of a certain candidate, a minority of those votes for the second choice of the Nominating Committee. That of itself is evidence to me which of the two men is the natural choice. Now, if the same choice was made between two other men, or the one that has the second vote and another man, the same conditions might exist. If that is good parliamentary law, I would be glad to see it carried out in that way, because it would simplify the handling of a matter of this kind when it does arise. But I do not see that we can interpret it that way. It does not strike me that that is the sense of a majority of the members of the society, and I have always understood parliamentary law to be an easy and sensible way of carrying out the will of the majority. That is all it is, and the assemblage of any body, society, or organization of any kind in general meeting has powers, of course, which are paramount to any powers delegated by them to any officers. Now, if a majority express their will in a certain way, I doubt if any parliamentary law can wipe out the decision of that majority, because parliamentary law is simply a means of accomplishing the results determined upon by the body itself. It is nothing else. It is rather a knotty question, coming as it does. We have never met it before, and I would like to see it straightened out.

The Chairman: Gentlemen, the motion made by Mr. Jellett is that the Nominating Committee proceed to nominate a candidate for first vice-president. That motion was seconded by Mr. Cary. The matter is before the house for discussion.

Mr. Andrus: I would like to make an amendment to that motion, and leave the selection of a first vice-president to the Board of Governors.

The Chairman: I rather doubt the legality of that. I think that in selecting your candidates, the Constitution distinctly says that there is to be a nominating committee.

Mr. Kent: Is there any necessity that we must settle this question to-night? If not, I would move that it be referred to the Board of Governors to report to-morrow afternoon some practical plan for dealing with the matter. (Seconded.)

The Chairman: Then the first vote will be taken on the reference. Those in favor of referring this matter to the Board of Governors, to report to-morrow afternoon, will manifest it by saying Aye; contrary minded, No.

The motion was carried.

The Chairman: I understand that the president's address is in the hands of one of the members of the society. Would that member, Mr. Kent, please read the president's address at this time?

The address of the president, Mr. D. M. Quay, was then read by Mr. Kent, as follows:

ADDRESS OF THE PRESIDENT.

It is with great regret that I find at the last moment that I cannot possibly be present at the annual meeting. I am especially sorry, since I now break the record of having been present at every other annual meeting of the society since its organization.

The society is to be congratulated on the progress it has made during the past year. The membership has increased, and the finances are in better condition, so that hereafter we hope to be able to publish the volume of proceedings promptly and without waiting for funds, as we have had to do up to this time.

At the close of the meeting last January, the Board of Governors appointed an Executive Committee of its own members, residing in or about New York City, to attend to such routine business of the society as could easily be transacted without requiring a quorum of the full Board. This committee has done its work to the entire satisfaction of the Board, and it is recommended to the new Board about to be elected that the plan be continued.

The reports of the several committees of the society will show that good progress has been made in the matter of our correspondence with the American Institute of Architects, concerning fees to be paid for engineering work. The Committee on Compulsory Legislation will also show that progress is being made, although slowly, in this work.

The society is now seven years old, and may be said to have

fully established its right to existence. What it needs now is an earnest effort on the part of membership to secure new members of the right kind; namely, those heating and ventilating engineers who are willing to contribute some of their knowledge of engineering facts, or their opinions on engineering theories, to our transactions, and by so doing place our society on the same plane as the older technical societies in other branches of the engineering profession.

The Chairman: The next matter to come before the meeting is the reading of a paper on "The Element of Time in Contracts," by Mr. Reginald Pelham Bolton.

Mr. Bolton read the paper, which was discussed by Messrs. Jellett, Kent, Connolly, McKiever, and Meyer.

Topic No. 1, "Methods of Ventilating Office Buildings," was then taken up for discussion. It was discussed by Messrs. Jellett, Meyer, Barwick, McKiever, Bolton, Cary, Yates, Kinealy, Barron, Stangland.

On motion the meeting then adjourned to the following day.

THIRD SESSION.

The meeting was called to order at 3 P.M. on Wednesday, January 23d, Vice-President Kenrick in the chair.

The Chairman: There being no further communications, the first order of business this afternoon will be the reading of a paper on "A Low-Pressure Hot-Water Heating System, Receiving Heat from a Steam Boiler," by John Gormly, member of the society. In the absence of Mr. Gormly, will the secretary please read that paper?

Secretary Mackay read Mr. Gormly's paper.

The Chairman: Gentlemen, you have heard the paper as read by your secretary. It is now before you for discussion. Does any member wish to say anything on that subject? If not, we will pass to the reading of the next paper, Mr. Gormly not being present to answer criticisms that perhaps might be made.

The next paper is "Some Notes on Central Station Heating," by William H. Bryan, member of the society. Will Professor Kinealy, who is a townsman of the gentleman, volunteer to read that paper of Mr. Bryan's?

Professor Kinealy read the paper, which was discussed by Professors Carpenter and Kinealy, and Messrs. Harvey, Payne, Bishop, B. H. Carpenter, Keyser, Davis, and Paul.

Topic No. 2 was then taken up for discussion: "What should be the velocities in the main ducts and branches in a forced-blast system of heating with a capacity of moving 25,000 cubic feet of air per minute, also in the air-supply ducts?" It was discussed by Professors Carpenter and Kinealy, and Messrs. Barwick, Jesse M. Smith, Payne, B. H. Carpenter, Sparrow, and Stangland.

The meeting then adjourned until the following day. In the evening a banquet was held at "The Arena."

FOURTH SESSION.

The meeting was called to order at 10.50 A.M. on Thursday, January 24th, Mr. Kenrick in the chair.

The Chairman: The first business this morning will be to listen to the report of the Committee on Compulsory Legislation.

Secretary Mackay: Mr. Adams, the chairman of the Committee, mailed this report Tuesday, from Baltimore, but it was wrongly addressed, and only reached us this morning. He was with us this morning, but was called away, and expects to get back this afternoon. He asked me to read this report.

REPORT OF COMMITTEE ON COMPULSORY LEGISLATION.

NEW YORK, January 22, 1901.

Gentlemen: The endeavors of your Committee on Compulsory Legislation have for various reasons not met with the success so much anticipated by the society.

Each individual member of the committee has made an effort to bring this question before the Legislature of his State. In Michigan the condition was such that a bill if presented would not have been acted upon. Mr. Harvey has this matter in hand in his State, and will do all he can and push it to a finish. In New York, Pennsylvania, and New Jersey, bills will be presented to the legislatures at their present session, and we hope for favorable results. In Maryland and also Illinois this matter has been brought to attention of the State boards

of health, and bills have been drawn up to be presented to the legislatures at their next session.

Respectfully submitted,
HENRY ADAMS.

The Chairman: You have heard the report, gentlemen. What is your pleasure in regard to it?

On motion the report was received and filed.

The Chairman: There being nothing further in the secretary's hands, we will take up the regular order of business laid down for the third day. The first thing will be the reading of a paper, entitled "Theory of Low-Pressure Steam Heating," by G. Debesson, Paris. Mr. Carpenter, of Wilkesbarre, has kindly volunteered to read that paper.

Mr. Carpenter read the paper, which was discussed by Professor Carpenter, Messrs. Joslin, Paul, Cary, Meyer, Mackay, Kent, and Payne, and Professor Kinealy.

The meeting then adjourned to 2 P.M.

FIFTH SESSION.

The meeting was called to order at 2.50 P.M. on Thursday, January 24th, First Vice-President A. E. Kenrick in the chair.

The Chairman: The first business that regularly comes before the afternoon session would be the report of the Board of Governors on the subject of standing committees. The matter was referred to them at the session of Tuesday. Are the Board of Governors ready to report?

Mr. Kent: At the meeting of the Board of Governors it was decided that, under all the circumstances, it would be better to let the standing committees remain on the list of committees as they are, the incoming Board of Governors, of course, having the power to change the membership if they see fit, but to let the four standing committees remain as the regular standing committees of the society.

The Chairman: Gentlemen, you hear the report of your Board of Governors. What action do you take in regard to that report?

Mr. Connolly: I move that it be adopted. (Seconded and carried.)

The Chairman: There was another subject referred to the

Board of Governors to report at this time, and that was whether there was a vacancy in the Board of Officers. Are the Board of Governors ready to report on that subject?

Mr. Kent: The Board of Governors considered that question, and thought the easiest solution was to report the subject to the incoming Board of Governors, and let them appoint a new vice-president. They will discover that there is a vacancy existing in the new Board of Governors, and by the Constitution they will have the power to appoint a new vice-president.

The Chairman: Gentlemen, you have heard the report of the Board of Governors. What will you do with it?

Mr. Cary: I move that the report be adopted. (Seconded.)

The motion was carried.

The Chairman: There was one other committee, gentlemen, which was appointed the first day, and that was a Committee on Resolutions, of which Mr. Snyder was chairman. Is that committee ready to report?

Mr. Snyder read the following report:

RESOLUTIONS IN REGARD TO THE DEATH OF MR. McMANNIS.

Whereas, The painful intelligence has been conveyed to the members of the American Society of Heating and Ventilating Engineers of the decease of one of its members, Mr. William McMannis, which occurred on the morning of the 19th inst., be it therefore

Resolved, That in this sudden bereavement we recognize the hand of the Omnipotent, and while we submissively bow to His will, we would record our sense of profound sorrow which, as individuals, and as members of this society, we experience for his loss to us and to the cause which he served with honor and distinction.

Resolved, That as a member he has challenged our respect for his superior abilities and his zealous application of them to every duty.

Resolved, That we bear testimony to the cordial relations entertained by him, and which his uniform courtesy inspired among the members of this society, and to his efficient labors amongst them in all things pertaining to the welfare, progress, and aims of the society, of which he was a charter member.

Resolved, That we recognize the indomitable energy of his nature, his sterling integrity, and the marked ability which enabled him to attain the eminence in his profession which he held, demanding due acknowledgment both in this society and public life.

Resolved, That these resolutions be entered in full on the minutes, and that the secretary be instructed to forward a copy, suitably engrossed to the family of our late associate.

C. B. J. SNYDER,
J. A. CONNOLLY,
A. HARVEY,
N. P. ANDRUS,
W. H. MCKIEVER,
Special Committee.

The Chairman: Gentlemen, you have heard the resolutions as presented to you by the committee. What action will you take as regards the said resolutions?

Mr. Joslin: I move that they be received and adopted. (Seconded.)

The resolutions were unanimously adopted by a rising vote.

Professor Kinealy: While we are attending to this miscellaneous business, I would like to introduce something which would perhaps come under the head of miscellaneous business, and that is in regard to a meeting next summer. We did not have a summer meeting last year. I think it would be of great benefit to the society in many ways, if we could have a summer meeting, and have that summer meeting at some place other than New York. If we continue to meet in New York, it seems to me that the society will be looked upon as a purely local New York society. I should like to see our society have one meeting, our annual meeting, in New York, and have during the summer another meeting at some other place in the country. I think that by doing this we would certainly increase very greatly the number of our membership. The question, of course, arises as to where we shall meet. I would like to see a meeting held in Chicago. Chicago ranks next to New York in size and importance, and there are many men out there who are eligible to membership in our society, and who, I think, would come in if we would hold a meeting there. I think

they would come in if they knew the society better than they now do. They will not come from Chicago to New York simply to be our guests or to attend one meeting unless they are members. The American Society of Mechanical Engineers usually has got an addition to its membership from those eligible residing in or near the cities in which they hold their summer meetings. For instance, they held a meeting in Cincinnati. As a result of that meeting, if not wholly as a result of that meeting, at least partly, there were eighteen new members elected, either from Cincinnati or in the immediate vicinity. Now, I think that if we should go to Chicago we would have a very much greater number coming in than the American Society of Mechanical Engineers had from Cincinnati. I therefore move that the Board of Governors be instructed to make an arrangement for a summer meeting to be held in Chicago.

Mr. Cryer: I second the motion.

The motion was discussed at length by Messrs. Cary, Snyder, McKiever, Secretary Mackay, Professor Carpenter, and others.

The Chairman: The motion made by Professor Kinealy was that the incoming Board of Governors be instructed to make an arrangement for holding a midsummer meeting at Chicago. Those in favor of that motion will please manifest it by saying Aye; contrary minded, No.

The motion was carried unanimously.

The Chairman: Gentlemen, the next thing will be the reading of a paper by Professor Carpenter. The subject is "The Proportioning of Hot-Water Radiation in Combination Systems of Hot Air and Hot-Water Heating."

Professor Carpenter then read the paper, which was discussed by Messrs. Blackmore, Kent, Mackay, Kinealy, and Cary.

The Chairman: We will now pass on to the next order of business, which is the installation of officers. I will appoint Professor Carpenter a committee of one to escort Professor Kinealy to the platform.

Professor Carpenter escorted Professor Kinealy, the president-elect, to the platform, and the other newly elected officers were then installed.

The Chairman: The next matter of business is topics for discussion. I take the liberty to say that there has been a topic

presented to me to-day which I think is of great value to every member of this association. That topic is as follows:

"Is there any method whereby a plenum can be maintained in supply to six or more rooms, where other rooms on the same supply line have doors and windows open?"

The topic was discussed by Messrs. Snyder, Cary, Kent, Barron, Professors Carpenter and Kinealy, B. H. Carpenter, Payne, and Mackay.

Topic No. 5 was then taken up for discussion:

"Is there any advantage or disadvantage in a gravity or fan system in taking the heated air from an indirect radiator casing at a lower point than the top of the casing?"

It was discussed by Messrs. Mackay, Connolly, Kent, Barron, and Blackmore.

The Chairman: Gentlemen, is there anything further to come before the meeting at this time?

Mr. Connolly: I move that we adjourn. (Seconded.)

The motion was carried.

SEVENTH ANNUAL MEETING.

The following members and guests were registered as being present during the meeting:

MEMBERS

Newell P. Andrus	A. A. Cryer	W. M. Mackay
Homer Addams	T. B. Cryer	W. H. McKiever
Henry Adams	Jas. H. Davis	H. C. Meyer, Jr.
J. J. Blackmore	C. G. Folsom	A. G. Paul
H. J. Barron	J. A. Goodrich	J. A. Payne
Thos. Barwick	Richard Hankin	H. H. Ritter
Chas. R. Bishop	A. Harvey	B. F. Stangland
J. A. Connolly	S. A. Jellett	P. H. Seward
F. K. Chew	H. A. Joslin	E. P. Sparrow
R. C. Carpenter	J. H. Kinealy	H. A. Smith
B. H. Carpenter	Wm. Kent	Wm. S. Washburn
Albert A. Cary	A. E. Kenrick	Warren Webster

GUESTS

S. F. Butterworth	J. S. Hamford	W. W. Macon
J. B. Bernhard	J. Hankin	R. W. Ryan
M. De Witt	F. D. Herbert	A. M. Schroeder
Chas. F. Frost	W. H. Hill	J. H. Smith
Jos. Graham	M. L. Kaiser	C. F. Webber
G. H. Hersey	W. A. Mills	

PAPERS

OF THE

SEVENTH ANNUAL MEETING,

New York, January 22, 23, 24, 1901.

LXXIX.

THE ELEMENT OF TIME IN CONTRACTS.

BY REGINALD PELHAM BOLTON.

(Member of the Society.)

Vexation and uncertainty surround this simple phrase to the engineering contractor. It is the one indefinite item in his estimates, the only unformulated feature in his studies, and yet the essential and fruitful cause of difficulty in his business.

In the nature of things, it cannot well be otherwise, but it is difficult for an impatient client or a distracted purchaser to understand such a statement.

It remains, however, the fact that all forms of construction involving the use of metals, are especially liable to delays, due to the nature of the materials dealt with, the variety of operations necessary to their formation into a completed shape, and where erected as part of a building, or other structure, to peculiar hindrances and delays of other parts of the construction, often to an extraordinary and quite unexpected extent, all of which are frequently inevitable.

In no other trade do so many elements contribute to this result. Tubes, plates, beams, angles and bolts, dependent on arrangements of mill management, compound structures involving forgings or castings which develop unexpected flaws and failures, and breakdowns of machinery operating upon all of the above, go hand in hand with the unwillingness or incapacity of workmen in creating unforeseen conditions.

The law upon the subject is in all countries as uncertain of application as the subject itself, and the legal faculty seems to have no definite or substantial grasp of the special difficulties of engineering construction, for the most part interpreting the law by that jack-in-the-box known as "trade usage," which is almost always sprung by one side or the other upon an unhappy and untechnical court.

The whip-lash of consequential damages, which is so often

held over the head of the delinquent contractor and manufacturer, is perhaps more of a bugbear than a reality, for the difficulty of demonstrating directly consequential loss has, perhaps fortunately, to be faced; nevertheless it is notorious that numerous cases of unjust penalties have been inflicted, not only by sympathetically-inclined juries, but by lenient arbitrators and judges, who not infrequently are led to decisions of such a nature, in cases where there is much contradiction, on the theory that where there is smoke there must be fire, or that delay is synonymous with negligence.

All this leads to the hope that when the codification of mercantile law is really and seriously undertaken, this question will receive early attention, and that it will be definitely made clear that claims for damage by delays, and excessive claims for consequential results, shall not be brought, as they are, only too often, for the sake of getting some advantage out of a disadvantageous purchase. It is well known that the law is thus misused for mean and dishonest attempts, and that its delays and ruinous cost are utilized as a means of unfair pressure in order to elicit concessions.

Cases in point could probably be cited by any engineering contractor, and would be multiplied indefinitely by the experience of other trades and professions. There are probably few firms of contracting engineers who have not undergone experiences of this character, and have, after the experience of one or two suits, wasteful alike of their time and money, brought themselves to bear with almost any material loss rather than fight with unscrupulous opponents, backed by the uncertain results of an ill-developed law and the ponderous unmanageability of its procedure. To the engineering contractor, standing as he does, between the owner and the manufacturer, and depending upon the willingness, not only of his own employees, but on their agreement with those of other trades, these remarks apply in full force, and the hopelessness of his position must excite pity, when —through no fault of his own, nay, even sometimes as a result of his praiseworthy anxiety to do justice to himself and his customer—he finds himself a loser by enforced deductions, penalties, loss of clients, or by being compelled to hold what he has purchased for his contract work, after his customers have declined its acceptance.

A contract containing, as most steam-heating contracts do, a rigidly fixed date by which the work must be completed, should only be accepted with the condition that all other work shall be advanced proportionately and regularly. It is now frequently demanded that the contractor shall provide overtime and night work if required to complete his entire work by the due date. The judgment of some experienced and technical person should be required as a referee to decide on the spot when such work is necessary or whether it has been caused by the delay of the contractor or of others. The provisions of the "Uniform Contract" in this respect are one-sided and unsatisfactory.

DISCUSSION.

Mr. Bolton: It seems to be very generally understood that if a man undertakes to carry out work within a given time, under a penalty for non-compliance within that time, that that penalty may be disregarded as being of no legal value, unless there should be also provided some equivalent in the shape of a bonus for completion in advance of the time. That, as some of you know, is a very false idea, as the elements of bonus and penalty are not interdependent, but it is an idea that is entertained, and even so recently as yesterday it was expressed to me by a very bright young man, who hastily assumed that liabilities of that nature were practically outside his consideration, because he did not have a corresponding bonus in his contract. I have in the course of my experience seen so many misunderstandings on the subject of penalties, and so much disappointment on the question of time in carrying out contracts, more particularly in this class of work, that I thought the paper would be of interest to the Society, and would draw out the views of many of those who perhaps have had more experience on the subject than myself. It would seem as if those who are engaged in entering into contracts of this nature should bear this question of time very cautiously in mind. But it appears very often as though they jump at the time that will be taken on a certain job, assuming that all will go well, and that everything will be carried out as expected, and leave very little margin for any doubtful features, such as the willingness of workmen.

My final remarks in the last paragraph in the paper, are those to which I wish to draw your special attention, as to whether or not in all such contracts, at the time when entered into, the judgment of an experienced and technical person should not be required as a referee to decide on the cause of delays in these contracts. That seems to be the point of difference upon which most of such cases get into the courts. The work goes along, delays occur, and troubles arise, and finally the parties get fighting each other, and there is no independent opinion as to why these delays occurred. In nine cases out of ten in all such matters, faults exist on both sides, and it would seem as if they could be settled very promptly if dealt with within a short time after having occurred. And finally, the provisions of "The Uniform Contract" in this respect are one-sided and unsatisfactory. That form of contract I recently dealt with in a paper before the Society of Mechanical Engineers, in which I pointed out a number of features wherein it is both one-sided and lacking. I did not draw attention to the elements concerning time in it, but if you examine it yourselves, and there is hardly a heating engineer here to-night, I am sure, who has not had some experience in contracts in which he has been bound by that form—you will agree with me that its provisions are not of a satisfactory nature; they do not cover either the just rights of contractor or owner in a satisfactory manner, and I understand by recent correspondence with the National Association of Builders that they have under consideration modifications of that form of contract which will tend to bring it more into line with modern conditions.

I leave the paper in your hands, hoping that we shall obtain your opinion on all the points brought forward.

The Chairman: Gentlemen, the subject matter of the paper presented to you by Mr. Bolton is before you for discussion.

Mr. Jellett: The Uniform Contract, to which Mr. Bolton has referred, was drawn originally for a builder to erect a building itself. It does not fit a mechanical plant. It takes a whole lot of interlining and typewriting to twist it so it will fit a mechanical plant, and the general result is an unsatisfactory arrangement. There is one thing I hope our Society will be able to do through its Committee on Uniform Contract and Specifications, and that is to draw up a form that will be ap-

plicable to our particular business, and it strikes me that it can be done; I do not see any reason why it should not. It is, of course, very difficult to make a form of contract that will cover all classes of work, but it is equally difficult to make a contract wide enough to cover all creation in any line of business, so that it can be made up in some form by which a power plant or a gravity apparatus or a blower system or general fittings remain the same, and that a page be inserted to cover the details of the particular engineering work on the contract, whether it be electrical or any other particular branch. Now, the question of time in contracts is one that is troublesome. The legal position varies in different States. There are places where the courts have held that without a bonus the penalty cannot be inflicted. There are also clauses that are valid in some places regarding ownership in materials. I know of printed forms of contract to-day that are sent out by large manufacturing concerns, in which they retain the ownership until the bill is fully paid, and it is legal in certain States. It is not worth the paper it is written on in Pennsylvania or New York. But there are States where it will stand. They get around it now in the South, where they equip large mills with machinery, by leasing the machinery until the thing is fully paid for, and the lease requires payments of 20 or 30 per cent. per annum covering the period in which the main payments are to be made. That is one way of retaining ownership. There have been a good many smart lawyers at work on that clause of retaining ownership until the final payments are made. There is the same variation on penalties and bonuses. I find in certain States that if you have a bonus attached you can hold a man to a penalty, but a penalty clause is one that wants to be carefully gone into before the contract is signed. There are conditions that it is impossible to fulfil at times, and there are men that are perfectly willing to take advantage of a penalty clause under those conditions. In a case of that kind I would not consider arbitration for a minute. If it was clearly a case absolutely beyond my control, and I was the contractor, and the owner insisted on holding me to the absolute penalty, I would go to a court, not to an arbitrator, because the courts would then determine the measure of damage, and if it is beyond human control on my end, that is taken into consideration.

The experience I have had with most arbitrations is that they are compromises. The majority of men that are selected as arbitrators—I have been an arbitrator myself, and I was of that kind—have not a legal mind; they are not trained to draw the line sharp and clear, and there are concessions on each side, and it winds up in some sort of compromise. Now, a compromise is an unsatisfactory arrangement to one of the two, afterwards, although at the time they may seem satisfied. In some contracts that I have signed within the last two or three years we have had a clause defining so many days after the completion of the building—the work shall progress as rapidly as the condition of the building shall permit, and shall be finished entirely within so many days after the completion of the building. That is a sensible clause. I have a case of my own now, of a contract that we have where our time penalty expired before we did any work at all in the building. The building was delayed by the non-delivery of iron during the great stress in the iron market last year, and our actual time limit, under a penalty of fifty dollars a day, expired before the material was on the ground. Now, no court would hold a contractor responsible under those conditions, because the building itself did not exist in which the apparatus was to be erected. But it is just as well to have those things clearly defined, if you can, at the time of signing the contract, and strikes and matters of that kind that are absolutely beyond your control should be exempt. There must be an equivalent of value on one side to offset the measure of damage on the other, and the experience I have had in matters of this kind is that an arbitrator is not a safe man on a technical point of any kind. A judge is nearer right than the average man whose business it is not to dissect such matters.

Mr. Kent: Mr. President, I wish that Mr. Bolton would supplement his paper by appending to it a form of time contract that we would approve, and in doing so I wish that he would consider not only the interest of the contractor, but the interest of the owner. I read his paper as presented before the Mechanical Engineers' Society, and there seemed to be that weak point in it, that he was generally in favor of the contractor, trying to let him out of a hole. But the owner ought to have something to say, too. If he has engaged the tenants to come in on the first of May, and it happens to be a cold May and the

heating apparatus is not in condition, he ought to have something to say about it. So that the equities of both parties ought to be considered in a time contract.

Mr. Jellett: The clause that I suggested, that the work shall progress as rapidly as the building will permit, and shall be completed in so many specified days after the completion of the building, because you cannot set up radiators and other materials until the floors and partitions are finished in the building, is the most sensible clause that I have been able to get hold of. If the builder has not the building ready for the tenants, the heating apparatus is not needed.

Mr. Connolly: I would like to ask for information. When you sign a time contract, and you begin the work as the building progresses, etc., and the owner makes certain changes, and places an order for extra work, has it not been always the case whenever there was a test in the courts, that the extra work has always barred out the time contract? I would like to hear from the members on that point. I think that is the way all the builders in New York get out of it. (There was no response to Mr. Connolly's question.) I guess nobody signs time contracts here, Mr. President.

Mr. Cary: At a meeting held by the junior members of the American Society of Mechanical Engineers, within two months, Mr. John C. Wait, who is a well-known authority on the subject of contracts and specifications, gave a very interesting talk on the subject of contracts. In this informal lecture some of the points which have been mentioned to-night were brought out, and among other matters considered was the requirement of a bonus clause, in case a forfeiture clause was made a part of a contract. I asked Mr. Wait pointedly at the end of his talk if such a bonus clause was necessary, and he said decidedly no; that the bonus clause was not a necessity to make a forfeiture clause valid.

Another point brought out by Mr. Connolly was also spoken of that evening, I refer to any change made in the contract after it has been closed. You must not insert any additional clause or make any change after a contract is once made and signed; any such change or alteration, according to Mr. Wait's interpretation of the law, would invalidate the whole contract, and so contractors must be very careful in this respect.

Mr. Bolton: I take the liberty of answering the questions before the close of the discussion. I think Mr. Connolly's question as to extra work vitiating the time element in the contract is rather an important feature, and should not go unanswered. I do not think that the condition as to time would be disturbed by extra work or would release a contractor from agreement to complete in time. A court would take reasonable conditions into account. It certainly would not knock on the head the entire condition or undertaking on your part to finish within a certain time. It might add to the time available, but only to the extent represented by the additional work.

Mr. Kent made a criticism upon my last paper, as well as upon this, I think, that it was rather one-sided, being written from the view of the contractor, rather than from that of the owner. I have this to say, and I am upheld in it by some authorities, that nearly all contracts are drawn from the point of view of the owner. I never knew of a contract to be drawn from the point of view of the contractor, unless it was a boiler contract. That certainly is the most one-sided thing I ever saw in the course of my professional career. It usually winds up with the clause that all verbal understandings and agreements that have been made are vitiated and wiped out by this agreement, and it does not allow the unfortunate owner anything to do except sign his name at the bottom. The general form of contract that is brought forward in heating work is a contract drawn up on behalf of the owner, and the owner is generally capable of looking out for himself, and generally employs a lawyer to attend to his interests. I therefore think there are a good many things in contracts which should be looked at in the interest of the other party, the contractor. He has his rights as well as the owner, and in a contract there should be no under dog at all; both parties should be on equal terms.

As regards the preparation of a general agreement for use in heating and ventilating contracts, this matter has received consideration by a committee of which I have had the honor, a rather barren honor, of being a member for the last year. I am sorry that they have been unable to accomplish anything decisive during the past twelve months, it being a subject, I think, that many people, capable of giving opinions of value

have shirked. My paper, to-night, may be taken as an instalment of my own studies upon the subject. It is a wide subject, and I think the committee can be excused for not accomplishing very much in the first twelve months that they have had this matter in hand. I think also that the views of members of the Society are as necessary as anything to their accomplishing very much in the preparation of a uniform form of contract. I should imagine it to be possible to form a satisfactory contract which heating engineers can look to as their regular form, and which they would be willing at all times to agree to. I want to say this, however, in conclusion: My argument has always been that it is necessary, in order to prepare a proper obligation between the two parties to such a contract, that the contractor or bidder must, at the time he is bidding, be aware of the conditions under which he is going to be bound. If you state, for instance, at the time when you are asking him for a figure, that you are going to bind him by the terms of a uniform contract, well and good; he can be assumed to have sense enough to find out that form for himself, discover what it implies, and find out what effect it is going to have upon the cost of the work he is to carry out. But if, as is done at present in ninety-nine cases out of a hundred, you simply ask for a bid upon the work, without stating the conditions you are going to bind him to, then it appears to me you are placing him in a very unfair position if you ask him afterwards to sign a contract with a number of conditions in it which may, and very often do, largely add to the cost of carrying out the work. I will ony take as an illustration of my point the very thorny subject of union labor. Let us say, for instance, you ask for certain work to be carried out in this city without saying a word about union labor. Bidders from different parts of the country figure upon the work, and they offer to do it for a certain price. You accept the offer of a certain bidder, and then draw up a contract in which the work is required to be done under the conditions of New York State law, say, as to stone work, or that the contractor must employ on this building nothing but union labor, or may use upon the building only union-made goods. Now you have brought entirely new conditions to bear upon the cost of the work, and that bidder would be perfectly justified in saying, "No, my

agreement with you (which I have already made, for your acceptance of my bid has made a contract between us which does not need any further instrument) settles all the conditions so far as I am concerned. I won't enter into any further agreements affecting cost without being paid for them." He is, in fact, entitled to extra remuneration for conditions not stated and therefore not considered in making a bid. But all that misunderstanding will be overcome if you have the features of the contract stated at the time that he makes his proposition. You tell him beforehand all the essential particulars of the contract by which you are going to tie him down. And that is where a uniform form of contract would be of the utmost value to members of the Society, because they might then make their propositions for so much money, under the condition that they should be bound by the provisions of a known form of contract that other heating engineers are willing to abide by. I think everything points to the value of a well-considered form of contract covering the work in which members of this Society are largely engaged, and it is certainly to be hoped that all those members who have ideas on the subject, or have had experience in any of these legal or technical points, will give the committee the benefit of their knowledge and advice, by correspondence or otherwise.

Mr. McKiever: Referring to the question which Mr. Bolton mentioned about a contractor being justified in refusing to sign a contract after he found a clause in it about union labor and union-made goods, the city to which, I think, he refers has found it expedient to incorporate with its plans and specifications a copy of the form of contract.

I do not quite agree with Mr. Jellett as to the clause that he would insert, for the reason that it would then bring in force the arbitrator whom he very much regrets to see in, and for the reason that it would be a question between the contractor and the owner as to the conditions of the building at the time necessary to start the work, and as to its being kept in progress with the building.

Mr. Connolly: I would like to take Mr. Jellett's part in answer to Mr. McKiever. I will ask Mr. McKiever a question through the chair. If he were asked to sign a contract tomorrow guaranteeing to give heat on the first day of March,

would he not be the first one to insert the words "provided the building be ready" arbitrator or no arbitrator?

The Chairman: Does Mr. McKiever care to answer that question?

Mr. McKiever: I would certainly say yes, Mr. Chairman, for the reason that I would know that the balance of power was on my side of the house.

LXXX.

A LOW-PRESSURE HOT-WATER HEATING SYSTEM.

RECEIVING HEAT FROM A STEAM BOILER.

BY JOHN GORMLY.

(Member of the Society.)

Inquiries are frequently made in trade journals by parties who submit sketches of peculiar situations in which a difficulty is found in conveying heat from one location to another. In some of these cases a modification of the device here described would apparently work with success. It is not presented because of originality in design, but because it possesses some features which may be of interest.

The writer was asked to heat a three-story dwelling by direct water radiation. The only flue available was connected to a vertical tubular steam boiler which carried, irregularly, from 25 to 150 pounds of steam, on the gauge; but had at all times some steam available. This boiler was in position in the basement of the dwelling, which was used as a milk factory.

The basement was but 6 feet high, in the clear, the water line of the steam boiler was within 18 inches of the basement ceiling. All radiation was to be located upon three floors above the basement.

Our first idea was to make a steam jacket through which the water for radiation could pass, and in passing, could absorb heat from steam admitted from the boiler into the jacket. The condensation was to be carried back by gravity to the boiler.

We had doubts, being so close to the water line of the boiler, that the jacket would fill with condensation, especially for the reason that the largest opening on the steam boiler was but 1¼ inches and could not be enlarged because the strengthening piece within the shell of the steam boiler was already too small and would not stand an enlargement of the tap. The owner was

not disposed to spend money that could be avoided, so we used the outlets as we found them.

When we turned steam on to the jacket it worked well for twenty-four hours and then turned cold. It was also noisy before turning cold. We found it apparently almost filled with condensation.

Because it had worked, apparently all right, for many hours, when the condensation was greatest, we now thought the automatic air valve was the cause of the flooding of the steam jacket.

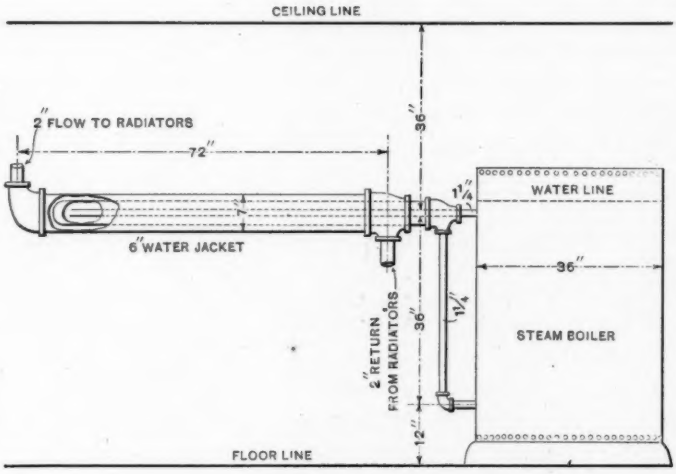


FIG. 1.

We changed the pattern of automatic valve in use several times. We then placed a hand valve instead of an automatic valve. We also took the precaution to leave it a little open all the time. It worked about twenty-four hours and then was flooded. We were convinced now that we were too close to the water line.

We theorized that the water in the steam boiler was as hot as the steam. We could not elevate, but could depress, our jacket. We therefore dropped the jacket below the water line of the steam boiler and made a water jacket of it. We connected a 1¼-inch pipe circuit between the boiler and the jacket below the water line of the boiler.

When we fired up with this arrangement it heated apparently as well as the steam jacket did at first. It is now in use six

winters and gives entire satisfaction. We did not suppose the water circulation would be swift in the jacket, because the return pipe is but 3 feet above the base of the steam boiler, giving a head of 3 feet to cause circulation. In the haste to connect up, and give heat, three 90-degree ells were placed in each connection between the boiler and the jacket. These necessarily retard the circulation to a certain extent.

I will endeavor to describe the steam jacket which was not successful, and the modification of the steam jacket which is a success.

The steam jacket was formed of three pipes, placed one within the other, concentrically. The outer pipe, to form the shell, is 6 inches in diameter and 6 feet long. It is placed horizontally with a 2-inch outlet upon the top near one end and a 2-inch outlet upon the bottom near the other end. These outlets are connected to the flow and return main of the radiating circuit. Because the outlets are on opposite ends of the jacket, all water of the radiating circuit must pass entirely through the heated chamber of the jacket.

Within the 6-inch shell of the jacket above described, we insert a 4-inch pipe with one end capped tight. The space, an annular ring, between the 4-inch pipe and the 6-inch jacket, is filled with the water of the radiation circuit. The interior of the 4-inch pipe, already described, is our steam space. The 4-inch pipe extends into the 6-inch jacket as far as possible, allowing room for expansion of the 4-inch pipe. The other end of the 4-inch pipe protrudes from the 6-inch pipe and terminates in a tee fitting. The 1¼-inch circulation pipe between the boiler and the jacket is connected to the tee fitting already mentioned. An air tube extends from the tee fitting to the extreme end of the inside of the 4-inch pipe. The outer end of this air pipe is connected to an automatic air valve. We placed the automatic valve a foot away from the jacket so that convected heat might not close the valve.

To change this steam jacket to a water jacket, we used the same 4-inch and 6-inch pipes, but in place of the automatic air valve and the air tube shown in the sketch, we placed a sheet metal diaphragm to insure an interior circulation.

The dwelling supplied by heat contains 393 square feet of direct water radiation, which, with the exposed mains added,

amounts to 491 square feet of direct water radiation. The dwelling contains 12,699 cubic feet of space, 344 square feet of glass, and 1,147 square feet of exposed brick wall. It is three stories and a basement in height, and is well heated now with a water circulation, which is supplied through a 1¼-inch circuit between the boiler and the jacket. We think the results remarkable, as the return circulation pipe, between the boiler and the jacket, has only an elevation of 36 inches, and is extremely small for the work it does.

LXXXI.

THEORY OF LOW-PRESSURE STEAM HEATING.

BY G. DEBESSON, PARIS, FRANCE.

(Member of the Society.)

SECTION I. GRAVITY CIRCULATING SYSTEM; OR, AMERICAN SYSTEM.

Let us consider a steam boiler A, provided with a safety valve, connected by its steam dome and its bottom with the two extremities of a piping BCDEF, of large diameter. Let us suppose this piping provided with a valve B at the top connection with

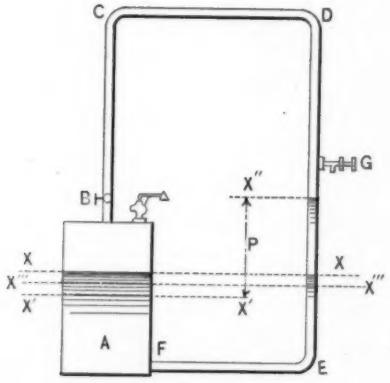


FIG. I.

the boiler, and carefully covered in order that no steam may be condensed in it, and properly provided with an air valve G.

The boiler not being fired, and its valves B and G being open, all the system is balanced; that is, the water line of the boiler and the piping are on the same horizontal level xx.

Let us now close the valve B and fire the boiler. In proportion as steam is produced, the pressure inside the boiler increases by degrees up to the limit allowed by the safety valve. At the

same time the water line successively falls to x′ in the boiler, and rises to x″ in the piping, and the height x′x″ between the two levels corresponds to the steam pressure P of the boiler.

If we now open the valve B, the steam flows through the piping BCDE, letting out all the air, which escapes through the air valve G. The velocity of flow is in proportion to the steam pressure, the diameter of pipes, and their resistance to flow (elbows, internal friction, etc.).

When all the air which was confined in the system has escaped and the steam begins to follow it, then let us close the air valve G.

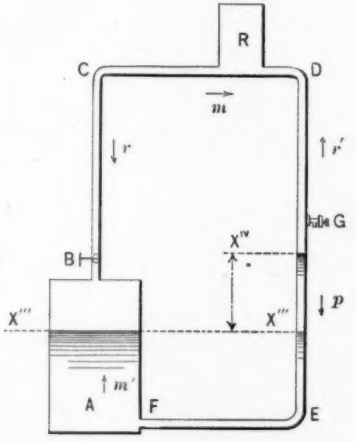


FIG. 2.

Another balance is now established, the water line inside the boiler and piping is on the horizontal level x‴ x‴ a little below xx, since some water has been vaporized. There is now no steam flow, since the system is balanced, and the piping BCDEF must be considered as a prolongation of the boiler.

Suppose now that a part of the piping is not covered, or better, that a radiator R is connected with it, the temperature of the surrounding atmosphere being low enough for condensing the steam which is inside.

Immediately a partial vacuum is created inside the radiator by the condensation of the steam, which calls for a flow through the piping BCD. Consequently the steam flows from B to the radiator with a velocity corresponding to the difference between

the pressures in the boiler and in the radiator, decreased by the friction and resistances of the piping.

The balance is now broken. In reality the steam will certainly flow from B to R in order to equalize the pressures; but if the distance BCR is longer than RDE, or if the resistances through the former are the greater, the water will rise in DE to x^{iv}. So long as there is a regular flow of steam we will be unable to maintain an equal pressure in the boiler, the piping, and the radiator. In proportion to the amount of the condensation of steam, the pressure inside the radiator will fall.

It may be possible, indeed, that for a time the velocity of flow may be able to balance again the steam pressure inside the whole system and definitively determine a level such as $x'''x'''$. In this case it will be necessary that the suction m, which results from the condensation of steam inside the radiator, reduced by the resistances r through BCR, equals the suction m′ which results from the vaporization inside the boiler, increased by the pressure p of the weight of water inside the pipe $x^{iv}x'''$ E, and reduced by the resistances r′ through the pipe RDEF. The equation of such a balance is given by the following formulas:

$$m - (r + r') = m' + p$$
$$m - m' = p + r + r'$$

For a level water line $x'''x'''$ it is necessary that $p = 0$, and then

$$m - m' = r + r'$$

It is the work of a pressure regulator to procure such a balance, very delicate work, indeed, and one that is rarely able to be accomplished. It follows from it that p hardly ever equals 0, and generally the water level inside the boiler and the piping are not in an horizontal line, which would be, however, the indispensable condition for a good operation of such a system.

This is the chief cause of knockings and rumbling noises which are often produced in the piping of the gravity circulating system.

Some engineers make use of a check valve placed near F at the bottom connection of the piping and boiler.

The water of the boiler, with such an arrangement, cannot flow back through the pipe FED. There is then a flow of steam

through BCD, and if the grades are properly provided the condensed water flows through DEF.

In this case, in order that the water may be easily reintroduced into the boiler, it is necessary that p be a little greater than, or at least equal to, $(m - m') - (r + r')$.

$$p \geq (m - m') - (r + r')$$

We may then say that the weight of the water column balances the resistances through the piping, as theoretically the quantity of steam produced by the boiler equals that condensed by the radiator.

This is the reason of the name "gravity system," which is given to steam heating with a closed cycle of piping.

It will be easily understood that the greater are the resistances $r + r'$ to the flow, the greater must be the height of the water column p. Therefore, in a steam-heating system with a gravity return of condensed water and a closed cycle of piping, it is necessary that we endeavor to reduce the resistances to the flow.

Whence the first objection to this system, that it necessitates the use of pipes of large diameters.

That the pressure of the steam must exist inside the whole line of piping, as well as inside the boiler, is the second objection to the system.

If we close the steam valve of a radiator, it is soon filled with condensed water, which flows back from the piping, even if the radiator is provided with an air valve, as the steam pressure is greater than atmospheric pressure, and that necessitates the use of a second valve, or a check valve on the connection with the return piping—a third objection to the system.

This second valve or check valve necessitates the use of an air valve to avoid a vacuum inside the radiator, because the atmospheric pressure would soon ruin the joints—a fourth objection to the system.

The water which is condensed in the radiator after closing its valves, and confined inside, must be driven out by the steam at every new opening of its valves, whence risks of noise—a fifth objection to the system.

We see that the gravity system with a closed cycle offers many objections; or at least many difficulties, which the science of the engineer is often powerless to overcome.

SECTION 2. GRAVITY SYSTEM WITH OPEN CYCLE, OPERATING AT THE ATMOSPHERIC PRESSURE, OR FRENCH SYSTEM.

The French system, which attempts to remedy the inconveniences above described, proceeds with quite another method.

Let us consider, as above, a steam boiler A and its piping BCDEF, with or without covering, but with no steam valve, and opened to the atmosphere by a pipe G without a valve. Evidently, as steam is generated, the water rises in the pipe ED until

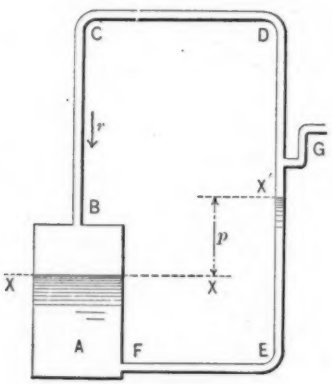


FIG. 3.

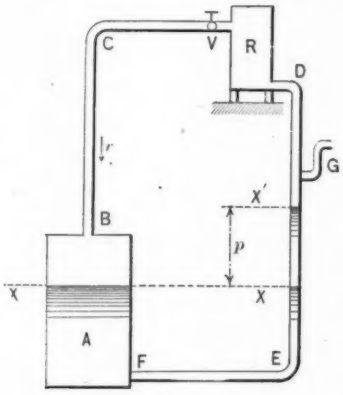


FIG. 4.

the difference between x′ and xx′ = p, equals this steam pressure. The steam flows through the piping BCDE with a velocity proportional to the steam pressure p, reduced by the resistances r, and escapes to the atmosphere through the open pipe G.

Let us suppose that a radiator R is connected with the steam pipe BC by a valve V, and with the return pipe without a valve, and that the valve V is provided with a system which allows to pass through it only the steam the radiator is able to condense. Let us consider the state of balance of such a system.

The pressure p in the boiler drives back the water to x′, through the return pipe ED. Inside the pipe BC is the same pressure, reduced by the resistance, and causing a flow with a velocity due to m − r. Inside the radiator R is a less pressure p′, corresponding to a velocity due to m′, since some steam is

allowed to pass through the valve V; also m' is greater than the atmospheric pressure. Inside the pipe DG is the atmospheric pressure.

These decreasing pressures then allow or determine a steam flow from the boiler to G. No steam being able to arrive at G on account of the special arrangement of the valve V, if the grade of the piping is properly disposed, all the condensed water freely flows down, by reason of its own weight, through the pipe Dx', and, therefore, by gravity, returns to boiler, when the vaporization of the inside water calls for it.

Such is our French system.

It is seen that it necessitates no air valve on the radiators. When the steam begins to be introduced inside the radiator, it forces back the enclosed air, which escapes through the return piping and pipe G to the atmosphere, and this as long as the valve V is full or partly open. As soon as this valve V is closed the vacuum inside the radiator calls for air, which is forced back into it by atmospheric pressure, but no condensed water is able to come back again, on account of its weight, and it is quite unnecessary to close the return connection of a radiator with a valve or a check valve.

This system then works without pressure inside the return piping, and the steam pressure of the boiler is used only to overcome the resistances through the piping and secure a perfect flow

$$m \geqq r$$

The internal diameters of these steam pipes may consequently be very small, and we have never more than a ⅜-inch pipe for our largest radiators of thirty and even forty square feet area.

SECTION 3. PRACTICAL DESCRIPTION OF SOME FRENCH STEAM-HEATING APPARATUS.

The method of erecting a steam-heating plant is quite different in France and in America.

In your country you have two different categories of engineers; namely, builders of apparatus, with numerous specialties—boilers, radiators, fittings, valves, pipes, etc.—and contracting

engineers, who estimate work, purchase apparatus, and erect the heating system.

We have quite another method. In France, each heating engineer has his own types of boilers, radiators, valves, regulators, fittings, built in his works, or according to his patterns.

A prominent heating engineer obtains patents for all the principal apparatus he uses for his work. He jealously keeps and claims his method, and it would be difficult, indeed, at the present time, to introduce your divided methods, for our annual heating work scarcely reaches ten millions of francs, distributed between half a dozen important firms, and thirty or forty less important engineers.

I intend here to give only a general idea of our usual methods, as there is very little difference in the methods of different firms.

I will briefly speak of (1) the pressure in steam-heating apparatus; (2) the chief type of steam boilers; (3) the regulators; (4) the radiator valves; (5) the piping.

1.—*Pressure in Steam-Heating Apparatus.*

Fig. 5 represents a rough arrangement of boiler. The expansion tank receives all the condensed water of the heating plant. The water line inside the tank is two meters, or six feet, above that of the boiler, which is the common steam pressure of our system. This tank is connected with the boiler by a feeding pipe A. An air pipe B, connected with the top of the expansion tank, is generally open under the grate. Another pipe, C, which is a safety pipe, connects the tank and the boiler just under the ordinary water line of the boiler, so that if the increasing pressure covers this water line, the steam flows through the pipe C, the tank, and the air pipe, to the atmosphere, cooling the grate and fire until a normal pressure is reestablished. When this increasing pressure comes suddenly, the water line rises inside the expansion tank, and flows through a little overflow pipe into a tank D, the weight of water immediately closing a flue damper, which stops the operation of the boiler. If this safety damper tank is bored with a very small hole, the water slowly flows out, and a counterpoise opens the damper and allows the flue gases to pass through the flue and the boiler to operate when the steam pressure is balanced.

These boilers are always provided with fuel magazines, the capacity of which is large enough to require only two coal fillings in every twenty-four hours.

We never use self-feeding water apparatus, as we know no good apparatus of this type. We know American apparatus, floating valves of every type, but we are not confident in their operation, as we often have impure waters, which are apt to unsettle their delicate arrangement. We prefer using an ordinary

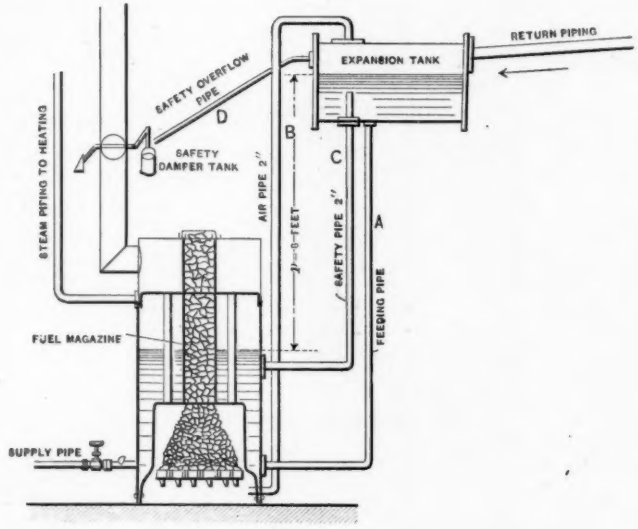


FIG. 5.

valve, which is easy to operate when the coal magazine is being filled. As very little steam or water escapes through the tank to the atmosphere, it is of no importance.

2.—*The Chief Types of Steam Boilers.*

I will say but few words on steam boilers. In France we don't like cast-iron boilers, and only the second class firms use such boilers. The highest class of heating engineers use only wrought-iron boilers, with riveted or welded plates. The chief

type is cylindrical tubular, with inside fire box and feed magazine, which is shown in Fig. 6.

This cut roughly shows the magazine, with six little air entrances above the grate, provided in order to burn inside the smoke flues the carbon monide which is often produced by slow combustion. The air entrance under the grate is regulated by the regulator, and the fire and ash-pit doors are connected together so that one cannot be opened without the other, which gives security against a negligence of the fireman.

Fig. 7 represents an arrangement of steam boiler by Messrs.

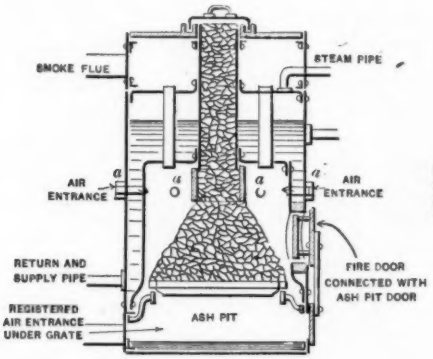

SMOKE FLUE
STEAM PIPE
AIR ENTRANCE
AIR ENTRANCE
a a a a are little holes or air entrances around the circumference of the boiler.
RETURN AND SUPPLY PIPE
FIRE DOOR CONNECTED WITH ASH PIT DOOR
REGISTERED AIR ENTRANCE UNDER GRATE
ASH PIT

FIG. 6.

Grouvelle and Arquembourg, who are among the leading engineers for steam heating.

A particular feature of their boiler is a large pipe connected with the boiler top and bottom. It contains an internal partition to insure having only dry steam inside the piping. It is this large pipe which furnishes steam to the manometer and the regulator. This regulator will be described below.

This boiler, which had a grand prize at our Exhibition, is one of the most perfect steam boilers, and has had many successful applications in our country.

M. Grouvelle, besides, is one of the teachers in our École Centrale des Arts et Manufactures, where our eminent engineers are educated.

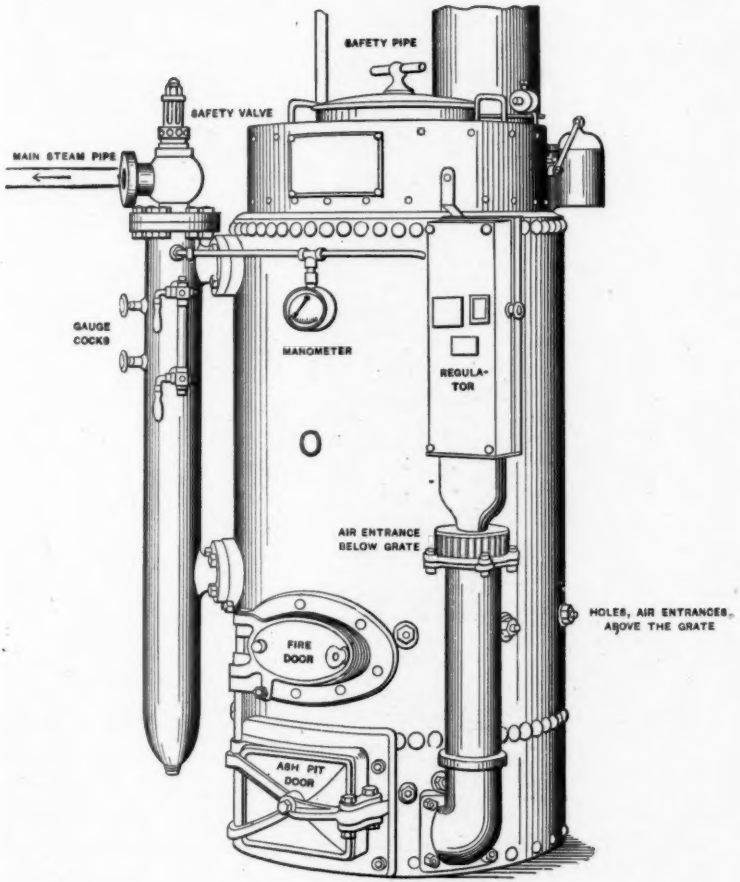

SAFETY PIPE
SAFETY VALVE
MAIN STEAM PIPE
GAUGE COCKS
MANOMETER
REGULATOR
AIR ENTRANCE BELOW GRATE
HOLES, AIR ENTRANCES ABOVE THE GRATE
FIRE DOOR
ASH PIT DOOR

FIG. 7.

The following cut (Fig. 8) shows the boiler of Messrs, Mathelin and Garnier, which is also one of the most perfect of its class. This boiler of welded plate iron is set in brick work and possesses many improvements. It has only recently been patented,

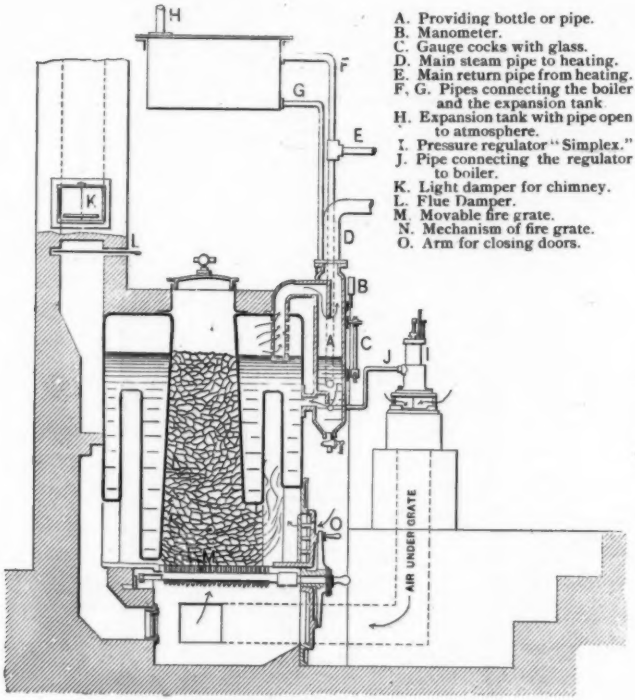


FIG. 8.

but it has already had many successful applications, and will certainly in future be a serious competitor to other makes of boilers.

3—*The Regulators.*

It is easy to understand that with such a low pressure a very sensitive pressure regulator must be used. Therefore engineers were obliged to very carefully study this apparatus, the action of which must be progressive, for very slight differences in the steam pressure.

The writer always uses American regulators (Fig. 9), with a rubber diaphragm, but with a special disposition of bars and counterpoises. Certainly these regulators are simple in operation, but I am not yet satisfied with them, and have had numerous disappointments with them. A regulator which is carefully adjusted when the heating system is newly erected is out of order a few days later, and this is certainly undesirable.

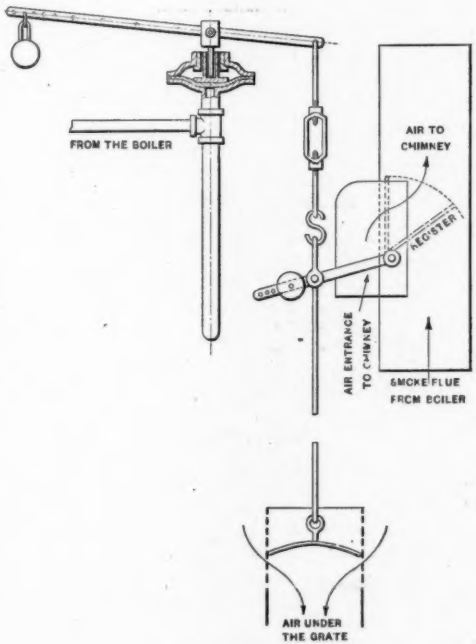


FIG. 9.

The molecular composition of rubber is rapidly modified; iron rust suddenly stops the working in numerous joints, and soon the regulator becomes sluggish. At the beginning of every winter it must be adjusted again, and the rubber changed. These are great objections to the system for our heating plants erected far from Paris.

The question of regulators is one which is most important, and we are certainly seeking for the best arrangement.

The Grouvelle and Arquembourg boiler is provided with a mercury regulator (Fig. 10) which is very well spoken of. It is sensitive enough to permit the regulation of the pressure in the boiler to that of one centimeter (four-fifths of an inch) of water column. This regulator consists of two small tanks A and B, filled with mercury, and connected at their bottom by an iron pipe. The tank A is closed and receives the pressure of the boiler through a little pipe a. The tank B is open, and

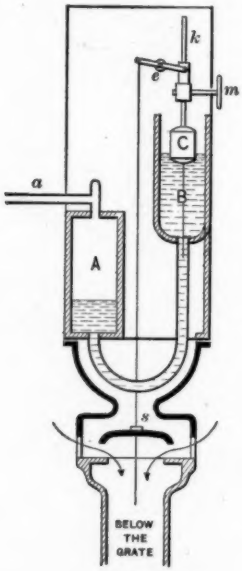


FIG. 10.

contains a floating counterpoise of iron C, which by a lever e actuates the damper s, which regulates the introduction of air below the grate of the boiler. The counterpoise does not act directly on the lever, but through an intermediate rack k, and a pinion governed by a button m.

This button is used to place the counterpoise in position at the proper height to operate at a predetermined pressure as indicated on a small scale which moves over a small hole in the casing of the regulator.

The operation of this regulator is very simple. When the steam pressure becomes sensible, the mercury sinks in the tank

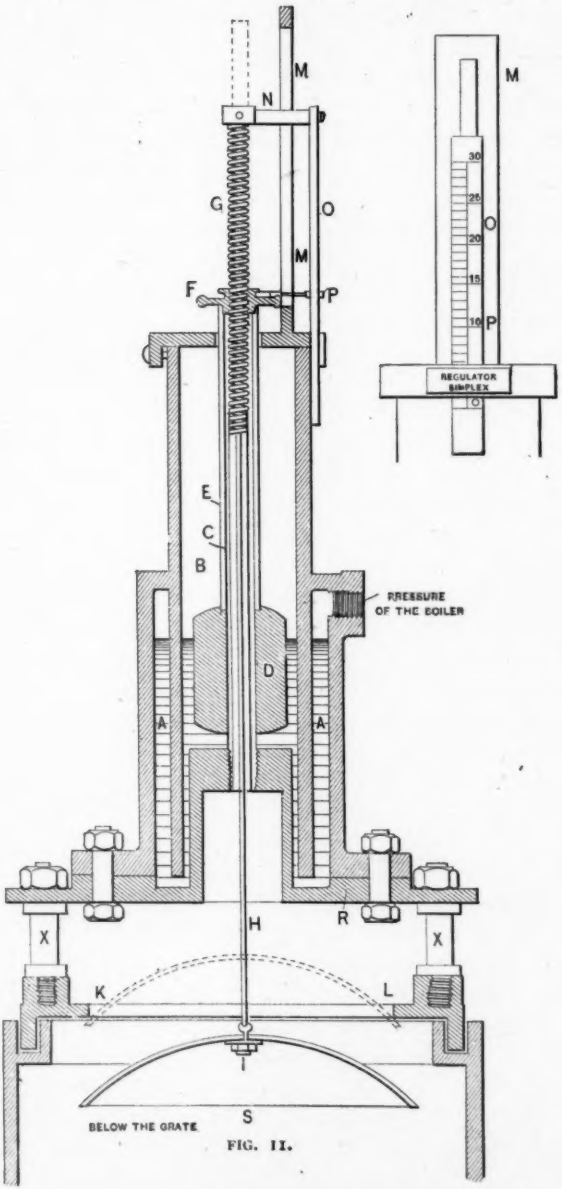

M
N
G
O
M
F
P
E
C
B
PRESSURE
OF THE BOILER
D
A
A
X
H
R
X
K
L
S
BELOW THE GRATE
M
30
25
O
20
15
10
P
REGULATOR
SIMPLEX

FIG. II.

A, and rises in the tank B, the difference of level in the two tanks corresponding to the pressure of the boiler. When the mercury in the tank B lifts the floating counterpoise C, the damper s closes more and more the air passage, decreasing the intensity of the fire and the pressure of the steam, and thus, with the above-named small limit of variation, maintaining the pressure of steam at the desired point.

The "Simplex" regulator of Messrs. Mathelin and Garnier (Fig. 11) has a similar principle; but we think it is superior because it has no articulation, no lever, no friction. It consists of two concentric tanks A and B filled with mercury, and an annular floating counterpoise D with a pipe guide C, placed through another pipe E, which translates the movements of the counterpoise to a little wheel F connected with an index P. The damper I regulates the introduction of air below the grate of the boiler through a flue S, which is able to close the opening KL. This damper is supported by a threaded rod H, screwed on the wheel F, and the guide N, supporting a scale O, movable over the plate M.

It is easy to understand that the operation of this regulator is the same as that of the preceding. By means of the wheel F it is possible to place the counterpoise at the proper height to operate at a convenient pressure, as indicated on the scale.

The regulator of Boechen and Fost (Fig. 12), which is sometimes used, is made of two concentric iron pipes; the interior pipe is open at top and bottom. The exterior pipe is movable and is closed at bottom. The interior pipe is connected at the top with the pressure of the boiler; the outer pipe is filled with mercury to a height sufficient to always cover the lower end of the inner pipe. The outer pipe containing the mercury is attached to a movable lever with a counterpoise, and to its bottom is attached a damper which admits more or less air to the grate.

As the steam pressure increases, the outer pipe is forced downward, the mercury acting as a frictionless packing and being prevented by its weight from being forced entirely out of the inner pipe. As the outer tube descends, lifting the weight on the lever, it also closes the damper, thus partly or wholly shutting off the draught. It is possible to adjust the steam pressure to any desired point by varying the position of the weight on the lever.

4.—*The Radiator Valves.*

A very important point in the French system is the radiator valves used. It is quite necessary, for the good operation of the system, that these valves allow only the passage of a quantity of

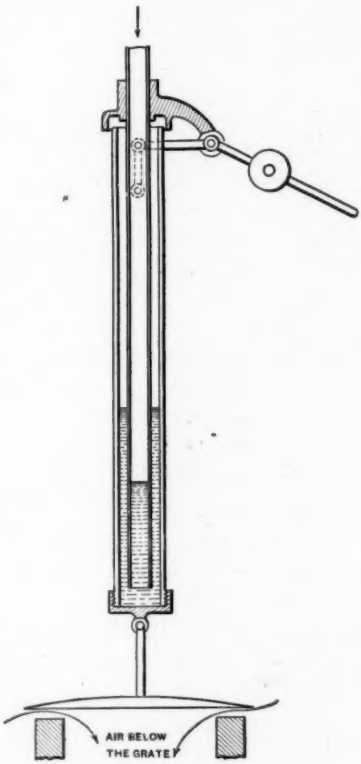


FIG. 12.

steam just sufficient to wholly condense in the radiators, so that no steam can pass through the return pipes.

Every radiator valve must then have two systems of regulation. The first, which is regulated by the heating engineer for the whole power of the radiator, the adjustment being made for the maximum steam pressure; and the second, which is at the service of the inhabitant of the heated room. The valve of

Messrs. Grouvelle and Arquembourg (Fig. 13) is a pointed gauge valve with conical seat. The guage A is graduated and set according to the surface of the radiator which must be provided. We think that this construction is objectionable, for it is only by experience that one is able to find the proper diameter of the gauge. This diameter may be computed for a determined pressure, but the pressure being not the same in the whole heating plant, according to the length of piping connecting the radiators to the boilers, it is only by trials of each radiator that we are able to determine the proper adjustment of the gauge.

The point of the valve has for its object the allowing of a gradual opening of the gauge, according to the degree that is necessary.

The valve of Messrs. Mathelin and Garnier (Fig. 14) has a similar principle. In this valve the opening of the seat does not vary, but the cylinder O is the variable gauge, and its diameter regulates the orifice of the valve. It may be replaced by one of different diameter threaded for the unchangeable screw B, so that the opening M may have a regulable area corresponding to the required flow of steam.

The Chappée valve (Fig. 15) is a cock valve, the opening B of which must be regulated by a threaded cylinder B which obstructs it at will in order to reduce it in the proper proportion. This valve has the great advantage of being capable of regulation at every moment during the operation of the heating system.

In the same class of valves we may name the old style valve of M. Leroy (Fig. 16). This valve has an inside gauge A, with several little holes, the diameter of which is graduated, according to the opening which may be required.

This valve may be adjusted at any time, even during the operation of the heating system. But the range in the regulation is limited, because the number of holes is determined by the diameter of the steam inlet through the cock opening.

Messrs. Leroy & Co., after using this valve during some years, now use their " Progressif " valve, patented in 1899 (Fig. 17).

This valve is composed of two cocks, in the plug of each of which is cut a similar triangular and circumferential channel or recess. The point of the triangle corresponds to a minimum aperture, and the opening increases to the base of the triangle,

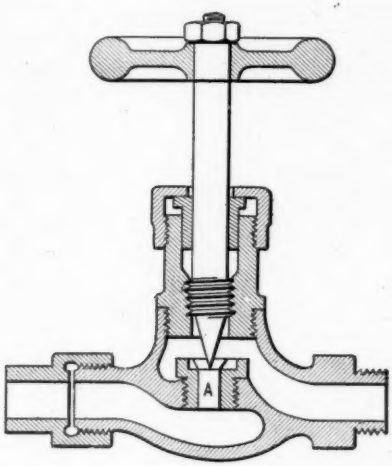


FIG. 13.

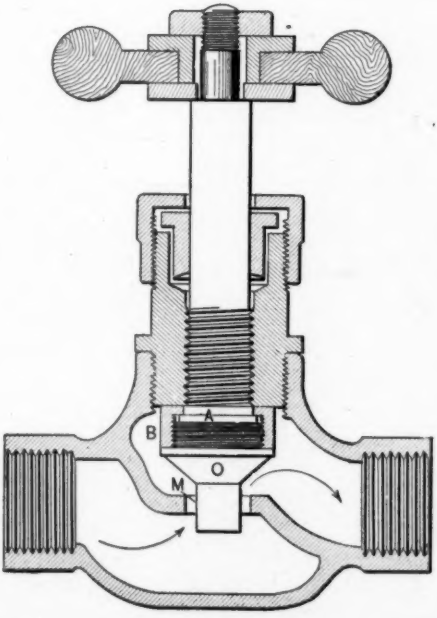


FIG. 14.

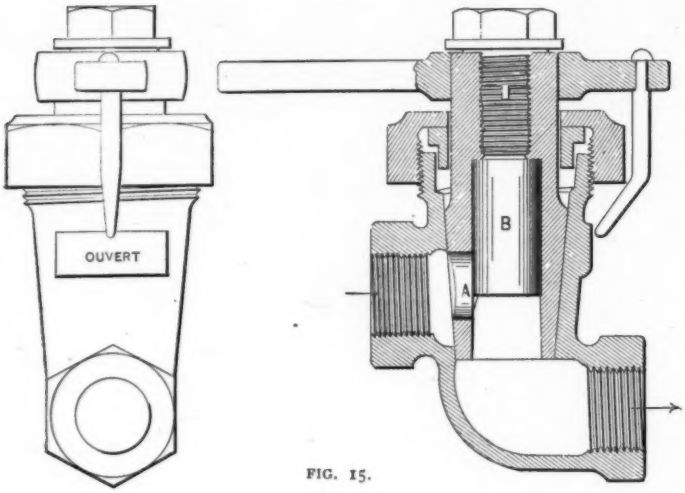


FIG. 15.

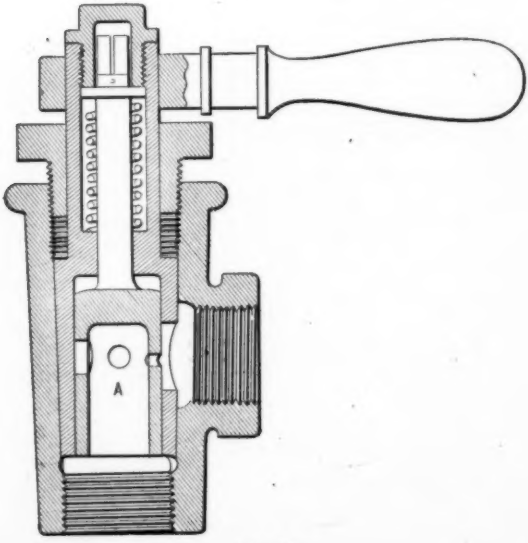


FIG. 16.

where it equals the section of the corresponding pipe. It is easy to understand the working of this valve. The first cock A is adjusted by the heating engineer for the maximum power of the steam apparatus. The second cock B must be adjusted for

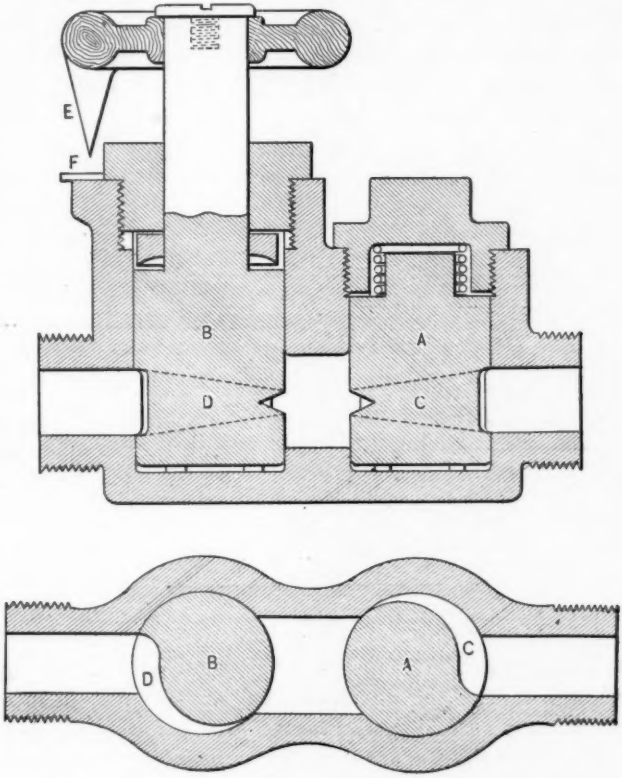


FIG. 17.

all requirements of the radiator as indicated by an index E moving on a dial properly graduated.

This valve or cock is successfully used with high or low pressure steam apparatus.

5.—*The Piping.*

We have very little to say on piping. In France we especially use wrought iron pipes, threaded and connected together by

cast or malleable iron fittings. Many engineers, and I am of these, use American fittings with conical threads. American goods are not generally used because we have not a uniform threading standard, and for a good commercial international exchange it would be a good thing to initiate this standard.

We have previously said that with our open cycle system we often use very small diameters of pipe. For these pipes it is often advantageous to use copper pipes, easy to be bent, without threadings and fittings.

For these copper pipes, one millimeter ($\frac{1}{25}$ of an inch) thick, $\frac{3}{8}$ inch, $\frac{1}{2}$ inch, $\frac{3}{4}$ inch, 1 inch and above, we use the special

FIG. 18a.

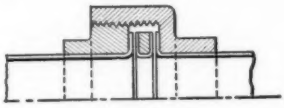


FIG. 18b.

FIG. 18c.

FIG. 18d.

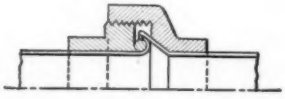


FIG. 18e.

connections described below. These connections have the great advantage of requiring no hard solder, and they may be made in a few minutes with no special tools.

We will give these connections with no special description, the cuts themselves showing the construction. With the Grouvelle and Arquembourg system (Fig. 18a), the ends of the pipes held by the two threaded parts of a bronze joint are simply placed opposite each other, and their friction, on account of the malleability of copper, secures complete tightness.

Messrs. Leroy & Co. place between the two extremities of pipes easily flanged out with hammer a special thick copper cold-hammered collar with asbestos between the two parts of the collar. (Fig. 18b.)

Another joint is made of a hard bronze ring, the points of

which penetrating into the copper secure the tightness. (Fig. 18c.)

M. Lebœuf uses an inside bronze ring (Fig. 18d), the extremities of pipes being only inclined and not quite flanged out.

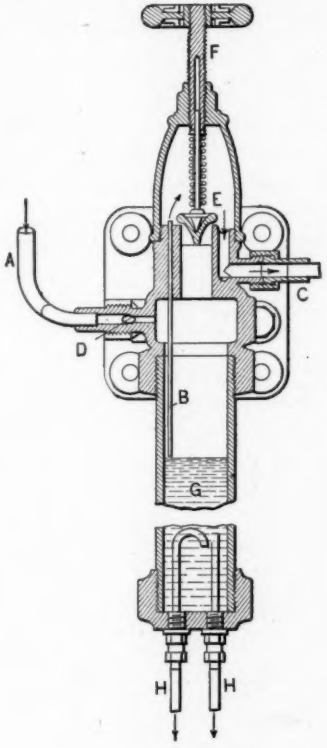


FIG. 18.

We have also the Vassé joint, made of an iron ring between inclined and flanged pipe ends (Fig. 18e).

Conclusion.

Such are the principal characteristics of our French apparatus. The writer would be pleased if he has to some extent interested the members of the American Society of Heating and Ventilating Engineers, and will be happy to receive their remarks on the subject.

FRENCH GOVERNED REDUCING VALVES.

The writer would be glad if the American Society of Heating and Ventilating Engineers could give him any suggestions concerning the apparatus designed in the two accompanying cuts. He has not seen in the American books and catalogues a similar

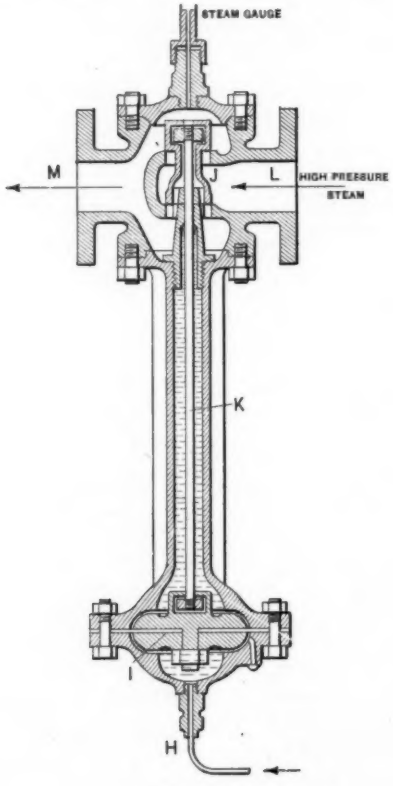


FIG. 19.

apparatus described, and, as it is very much used in France, he is anxious to learn if it is possible to buy in America apparatus giving the same result.

The governor, or service regulator (Fig. 18), is an apparatus receiving the steam at whatever pressure through a pipe A. A gauged orifice D, allowing to pass only the steam which may be

discharged through a very small pipe B, and a pipe C to the atmosphere, the pressure into the service regulator falls to the limit allowed by a safety valve E, itself regulated by a wheel F acting on a spring.

A convenient pressure is so translated to the inside water G, and through the very small pipes H, H (Fig. 18), to reducing valves (Fig. 19), which must be as numerous as it is necessary.

In order to prevent the freezing of water inside of pipes H, H, it is mixed with glycerine.

These reducing valves (Fig. 19) have no unusual features. A double valve J is governed by a tail K and a rubber I. This rubber is placed in a chamber, and below is transmitted through the little pipe H the pressure fixed by the governor, or service regulator, so that whatever may be the original pressure of the steam in pipe L, the pipe M always delivers this steam at the desired pressure.

It is easily understood how important such an apparatus is in a steam-heating system in steam vessels or in large buildings which have many steam boilers.

Let us suppose a large works provided with two, three, or more boilers, with the same or different steam pressures, and the offices which are to be heated located at very long distances from one another. It is possible to have such regulated reducing valves connected with the several boilers, and all these valves governed by the same service regulator, so that at any time the chief engineer is able to control and register together all these valves to the same desired pressure.

DISCUSSION.

Professor Carpenter: We are very much indebted to Mr. Debesson for the excellent paper that he has presented, and especially for the full description that he has given of the French practice. It strikes me that in working out the theory of the American system there is either some misinterpretation of the original paper, or a misunderstanding of the American system. I think his mathematics are perfectly correct. I am rather inclined to believe that he holds that the American system is laid out to work much the same as the French system; whereas, the American systems are laid out so that both return pipe and

steam pipe—one carrying water from the radiator, and the other carrying steam to it—are relatively very large; consequently no suction, or what I understand to be the equivalent of "suction," is possible. We have the full circulation of the steam. We do, however, have otherwise just the same action that he describes, so that I take it we get exactly the same conditions which he expresses in these equations. That is, we have on the one side the steam pressure which is reduced by resistances of the pipe; on the return side, we have the steam pressure, which is also reduced by the resistances of the pipe, and is increased by the height of the water line of the return pipe above the boiler, which would come out exactly as he has expressed it in the form of an equation. It seems to me that the French system described here is a very peculiar one. I had not realized that there was in use a system which is so complicated as this. The idea in the working of the system, as I get it from this description, is to practically condense all the steam which leaves the boiler before it gets back again, and consequently very small return pipes are permissible. Instead of appearing to me simpler than the American, it seems to me more complicated. This gentleman speaks of it as simpler than the American system; but he has to have a great many valves for accomplishing his purpose, and what seem to me a good many complications.

Mr. Joslin: Mr. Chairman, the system which has been described here to-day has been used in this country for the last fifteen years. I have seen plants myself which have been put in. It is what is called the Tudor system—a fractional valve system—only Mr. Tudor brought the returns from each radiator down one story, some twelve or fifteen feet, and put a check valve upon them before connecting into the return line, depending upon the column of water on top of the check valve to open it and discharge the condensation, against the minus pressure in the radiators, and the return pipes from that point went back into an open tank. In the system described in the paper he blows the steam out of doors. He must have a little pressure in his radiator in order to get the air out of it, and after the air is out, of course, he can make use of the fractional valve. I think there is a Tudor system in operation almost across the street, over in Fifth Avenue.

Mr. Kent: How extensively has that been introduced in this country?

Mr. Joslin: For the last twelve or fifteen years; not many within the last twelve years. But Mr. Tudor put a great many of them in originally when he first got the patent out in 1885. I know there were several in Boston and in New York at that time. He had his valve graduated, so that he could open it a quarter, a half, or three quarters. But he did not take into consideration the question of getting rid of the air any more than this gentleman does.

Mr. Paul: There is one thing more I might say in regard to this Tudor system, which was patented in 1885. Mr. Tudor had a system that went a little farther than Mr. Joslin has indicated. He had a system in which he did not have the loop at all; but he had a straight return, the same as shown in the French system mentioned in the paper. He put a condensing radiator on the end of the return pipe, so that if any steam did go through the radiator in the room, it would be condensed in the end radiator on the return pipe, using that as a condenser. He placed an air valve in the basement of the building, one air valve for the whole plant, so that whenever the circulation was once established, the air valve would close. He had a reducing valve on the supply, so that he could maintain a certain fixed pressure in his supply mains, and then in addition to having a fixed pressure in the supply main he had what he called his fractional valves. These fractional valves were graduated to three different graduations. They were also arranged so that if the persons who were occupying the building should close the valves the night before, and the weather should grow colder while the persons were away, it was possible by increasing the pressure on the supply main to open every valve in the building and put the steam into all the radiators. If Mr. Tudor had only been able to take care of the resistance to the flow of steam, to get the air out, etc., his system would have been in very good shape.

Mr. Joslin: In other words, the Paul system. (Laughter.)

Mr. Paul: Let me say something on the question of reducing valves. The reducing-valve question, of course, in my business has been quite a factor. If we try to carry a uniform pressure, we find it is almost an impossibility if we have a number

of reducing valves, as two reducing valves, or three or four working together, will never give exactly the same pressures; so our practice is to use only one reducing valve. It is possible to take the simplest form of reducing valve, and by arranging it so that it is controlled from the point whose pressure you desire to control, to get a uniform pressure throughout the entire plant. When I say the simplest form, I mean merely a balanced valve controlled by a rubber diaphragm, and the rubber diaphragm controlled by a pipe from the point where you desire to have a certain fixed pressure. That pipe can be run any length. It can be run—well, any number of hundred feet from the point where your valve is.

Mr. Meyer: I am curious to know why there is an objection to cast iron boilers in France, and if the author would give some information in regard to that, I think it would be of interest. I believe in Germany there is a similar objection to boilers made of that material, due to the fact that they are required by law to stand a very much higher pressure than they commonly work under in practice. Perhaps that same reason may hold in the author's country.

Secretary Mackay: I rather think that the objection to cast iron boilers in France is due to the fact that this type of boiler is not made there. They make wrought iron and steel boilers there, and use them largely. When American boilers are imported into France they have to be fitted in a certain way. That is, they require a double arrangement of gauges, try cocks, safety valves, and appliances throughout. Even the safety valves have to be in duplicate and have to be graduated in millimeters. Then when you comply with the government laws you are not free; your boiler is inspected by a government inspector and condemned, and when it is condemned it cannot be used. There is no reason given. The boiler would stand the pressure. I think it is merely an effort on the part of the French Government to protect French manufacturers to the exclusion of foreign manufacturers. I think that is the only reason. I have had a little experience on that particular line in exporting boilers from this country into France—cast iron sectional boilers, that the second-class firms of France use, according to Mr. Debesson's paper—and after paying the freight and the duties, and complying with all the

laws, and installing them, they were condemned. We even cannot get the duty refunded. I know of American boilers that were exhibited at the Paris Exposition, cast iron sectional boilers, which were awarded gold and silver medals; there was an effort made by the American commissioners to have them remain there and be used. That was done to save freight back to this country. But I think that all of the manufacturers with the previous experience decided that it was best to have the goods returned. They would be of no earthly use for them or to people there.

Mr. Cary: I know that I am venturing upon dangerous ground when I rise to say anything against the cast-iron boiler here among its many friends, but I feel I must confess that I do not like a cast-iron boiler, although at the same time I am forced to admit the necessity for its use.

For many reasons wrought iron is very desirable for the construction of heating boilers, being somewhat less liable to destructive pitting and rusting than is a boiler made of steel, but it is well known that a cast-iron boiler is less liable to suffer from pitting and corrosion than is either wrought iron or steel, and as such deterioration is a matter of considerable importance in heating boilers, it makes a cast-iron boiler the most desirable when viewed from this standpoint alone.

On the other hand, when resisting internal pressure, the cast-iron boiler is, by far, the least desirable of the three, owing to the comparatively low strength of the metal in tension and its lack of ductility. These points of weakness make such boilers dangerous and the most liable to explosion.

I was called upon not long ago to investigate the explosion of a cast-iron boiler which had caused considerable damage. The boiler was one of a well-known type and make which is sold in considerable numbers for heating houses.

I found, in this case, that the boiler was used to heat the hot-water supply of three apartment houses, being connected to a supply or storage tank in such a manner that the water from the bottom of this tank entered the boiler through one pipe connection, and after becoming heated, left it through another pipe conection, returning to the opposite end of the bottom of the storage tank. The size of this storage tank had been calculated to supply only one house with hot water, but after the

owner bought the two adjoining houses, he also connected *their* hot-water supply pipes to this same storage tank, which, of course, was too small for such service. The result was that the small cast-iron boiler had to be forced, in its firing, to a very high capacity, and even then there was such a small storage space for the hot water, when a large and simultaneous demand came for hot water throughout these houses, the supply was soon exhausted, and the storage tank was soon filled with cold water, which flowed directly into the boiler. In all probability, at one of such times, when the boiler was being forced, steam gathered in pockets where it could not escape, and in rushing cold water condensed it suddenly, causing a water hammer, which ruptured the boiler and caused the explosion. The violence of this explosion can be appreciated when I say that it broke the boiler into many pieces and scattered its parts all over the cellar. It broke every cellar window and a number of those on the floor above, and even broke some large windows on the opposite side of the street. It further blew down a cellar partition, blew down some doors, and did considerable other damage. Fortunately no one happened to be near it at the time, so it did no personal damage.

The boiler, under normal working conditions, was under from 30 to 35 pounds constant pressure per square inch, due to its receiving its water supply (through the storage tank) from a supply tank on the roof, and when under such constant tension it was all the more susceptible to rupture from a blow.

On examining the broken parts, I found the castings made of a good, even, close-grained cast iron, and with no signs of brittle metal apparent anywhere; but I found a considerable lack of uniformity of thickness, the metal running all the way from ⅝ inch thick to ¼ inch thick.

Besides the lack of strength and ductility in the metal composing a cast-iron boiler, there is bound to be more or less variation in its thickness, due to shifting cores, and "rapping" (to loosen the patterns in the sand) in the foundry, and therefore, how much strength we have to resist internal pressure in various parts of the boiler is always an unknown quantity, which no reasonable hydrostatic test can determine.

Most castings, especially thin ones, carry internal strains due to more or less rapid cooling just after they leave the mould,

and also due to shrinking strains, and when with all such inherent troubles we add the strains of unequal expansion and contraction occurring when the boiler is in operation, it is certainly to be wondered at that there are not more accidents occurring to such boilers than there are.

Mr. Joslin: Mr. Chairman, on the fourth page of this paper it says: "This second valve or check valve necessitates the use of an air valve to avoid a vacuum inside the radiator, because the atmospheric pressure would soon ruin the joints." I would like an interpretation of this. That is one of the objections he makes to the gravity system: "Because the atmospheric pressure would soon ruin the joints," and in his own system he makes use of atmospheric pressure all the time. I do not understand why atmospheric pressure should ruin a joint.

Professor Kinealy: In regard to what Mr. Joslin says, I think the reason is because of some peculiarity in the packing of joints. If there is a vacuum inside the system, then there is the pressure of the atmosphere outside, tending to make the air go in through the joints—not that it would rust them or anything of that kind, but that here would be a blowing-in process. When there is a vacuum in the system, then, of course, you get the atmospheric pressure on the outside, and there is danger of blowing in the joints or of collapsing some part of the apparatus. Of course, the author of the paper does not say how he packs the joints, or how he makes them; but that is the way I understood this when I read it. Mr. Cary has said something about cast iron boilers, and he evidently has been looking into the matter. I should like to know if he or any other member has any suggestion as to the per cent. of cast iron boilers which explode. It seems to me that is what we must judge these things by—the percentage of cast iron boilers that explode, and compare that with the percentage of wrought iron or steel boilers that explode. That, after all, must be the test.

Mr. Kent: In regard to the cast iron boiler question, I saw this boiler that Mr. Cary speaks of; that is, the remains of the boiler, and the trouble was that it was a very bad form of boiler. It ought never to have been put in that position. I think it would not have exploded if it had been one of the ordinary

styles of cast iron boiler which are divided up into small sections. These sectional boilers seem to have come into use almost universally. I think there is no question that nine-tenths of all the steam heating done in the United States in very small plants is now done by these small cast iron boilers, and engineers recommend them in preference to wrought iron boilers on account of the greater durability. And there is very little trouble indeed in these modern types of cast iron boiler where the cast iron is divided up into small sections. The question of shifting cores is apt to happen, of course; but with good foundry practice it ought not to happen seriously, and that could be checked by testing to find out if there is any weakness in it. I think if a cast iron boiler intended for ten pounds' pressure is subjected to a proof test of fifty pounds, it would be reasonably safe.

Mr. Cary: The makers of this boiler assured me that it had been tested to between 60 and 70 pounds hydrostatic pressure before it left their works, but it had been demonstrated many times that a very thin shell will withstand a surprisingly large hydrostatic pressure and rupture in actual work shortly afterwards at a pressure far below that applied during test. I regard such a test alone very unreliable when used to prove that the boiler is safe to work at, say, 50 per cent. of the pressure thus applied.

When water hammer occurs in a cast-iron boiler, I do not believe that its safety depends to any degree upon its form or design. Referring to the boiler I have described, I believe that under similar trying conditions *any* other form of cast-iron boiler would have similarly ruptured.

There is on the other side a very important fact in favor of the cast-iron heating boiler. The majority of heating boilers are operated only during a part of the year, lying idle the balance of the time, and during this time of inoperation, when steel or wrought-iron boilers are used (unless they are properly cared for), more or less serious rusting and pitting occurs which does not take place in cast-iron boilers similarly situated; but notwithstanding this extra care needed, I consider a wrought-iron boiler better and safer than one made of cast iron, and I believe that those who have given this matter careful and unprejudiced thought will agree with me.

Mr. B. H. Carpenter: I do not know that I really understood the condition of this boiler that Mr. Cary speaks of, but had it been a wrought-iron boiler under the same conditions, would it probably not have exploded? I understood the tank was not large enough to furnish the supply of water to the boiler. Am I right in this?

Mr. Cary: The supply of water to the boiler was independent of the size of the tank, but this storage tank was not of ample size to store sufficient hot water to supply all three houses, and in consequence, due to a large demand, the storage tank was quickly emptied of its hot water, which was replaced by cold, and this cold entering water probably came into sudden contact with steam existing in the upper part of the boiler, causing a water hammer followed by collapse.

Mr. B. H. Carpenter: Would not the strain have been about as serious on a wrought-iron boiler?

Mr. Cary: Undoubtedly the strain would have been as great, but to resist this shock we have a ductile, elastic metal of much greater tensile strength, and for this reason I question the possibility of such an accident occurring.

Even had a rupture occurred in a wrought-iron boiler similarly operated, it would doubtless have been much less extensive, as the cast-iron boiler simply went all to pieces, thus liberating the pressure. It was not a steam-heating boiler for heating a house, but it was a boiler for heating hot water.

Mr. Paul: As I understand Mr. Cary, the boiler that went to pieces was a boiler which was furnishing hot water, and that they drew more hot water than the boiler could supply, and as a consequence cold water came in. I did not understand that it was a steam-heating boiler for heating a house, but it was a boiler for heating hot water.

Mr. Cary: Mr. Paul is correct as far as the direct application of this boiler is concerned, and I have merely introduced it in my discussion to illustrate the position I have taken, and I believe it serves this purpose aptly.

Mr. Mackay, in his discussion, spoke of testing cast-iron sectional parts when they left the foundry and before they were finished, and he stated further that, after they were finished, they were tested again, not to find the soundness of the metal, but merely to test the joints.

I was, for a number of years, connected with a concern making sectional boilers, and as a result of experience, we gave up the practice of testing by hydrostatic pressure, just after the castings left the foundry. At that time the castings were carefully inspected, and all parts showing visible defects were rejected. After inspection, machining these castings would occasionally develop further defects, and those parts which stood inspection after machining were *then* tested hydrostatically.

Our experience was that many castings containing defects, such as blow holes, cold-shuts, and spongy metal, would not develop these troubles under water pressure just after leaving the foundry, on account of their being hidden beneath the surface of the outside scale, but after thorough cleaning and machining (which would expose a certain part of the casting's interior) trouble was frequently developed which could not be detected before. The heavy milling processes sometimes seem to jar or vibrate the metal sufficintly to crack the outside scale over defective points and let water (under pressure) through.

Mr. Meyer: Mr. Chairman, I had occasion in the past seven or eight years to investigate such explosions of house-heating boilers as came to my notice. But I think in almost every one of them, where I could get any information at all that seemed to be of any value, the primary cause of the explosion was due to a defect in the heating apparatus, and not to a defect in the boiler. In some instances it was due to the freezing of the expansion tank in cold weather, or the pipe leading to it. In one or two instances that I have known of, the expansion tank was connected to a certain riser line which contained a valve between the expansion tank and the boiler, so that when that valve was closed the boiler exploded. It seems to me that American cast iron boilers have given most excellent satisfaction, and I think we ought to let the author of the paper know, rather than have him gather the impression that they are dangerous—because this paper will undoubtedly go back to France, and perhaps be more or less quoted and talked about there—that if the French people use the simple boilers that we have in this country they will probably have less trouble with the heating apparatus than they have now.

Secretary Mackay: I think that in some of the discussion we have been getting a little away from the subject. The sub-

ject is the discussion of a paper on the theory of low-pressure steam heating, and we have been bringing in high-pressure, hot-water apparatus, and by doing that condemning the cast iron construction of boilers. Then we have brought in the statement that cast iron boilers are used only for a short time during the year, while the wrought iron boilers are used for a longer time, and I do not know any reason why wrought iron heating boilers should be used any longer in a building than cast iron heating boilers. I have followed up the question of house heating for some thirty years, and have been during that entire time connected with the construction of both wrought and cast iron boilers for heating purposes. This is a heating apparatus that we are discussing; and while wrought iron boilers have been wrongly constructed at times and have gone to pieces, it does not condemn the wrought iron or the steel boiler because of some mechanical defect in construction. In the cast iron boilers there have been the same defects. Moulders have improperly secured their cores, and the cores have raised. We have had ⅛-inch thickness at one part, while we have had ⅝ at another, and the intention was to have it ⅜ uniformly. Sometimes those defects get away from the foundry without being detected, even after a test, still I do not think they amount to a very large percentage of the cast iron boilers that come from the foundries. The general practice with cast iron sectional boilers, as used in this country to-day, is so to construct them that they will stand a very heavy pressure as compared to the pressure that they are intended to carry uniformly while heating buildings. Some of the better types of them are subjected to an initial pressure of 125 pounds before any work is done in the way of machine work on the castings (that is, of the sectional type). They are then completed and put together by whatever method the manufacturer employs, and are tested to a pressure of about 80 pounds, for the purpose of merely testing the joints, the perfectness of the casting having previously been ascertained. Those boilers in general practice are expected to carry from 5, which is the average practice, up to 25 or 30 pounds. I know of very few heating boilers that are sent out with a safety valve that will carry over 25 or 30 pounds. The steam gauges are graduated about 5 pounds beyond what the safety valve

will carry, probably as high as 30 pounds, and in connection with the manufacture of half a dozen of the best types of American boilers, the percentage of explosions or damages through defects in construction is very, very small; and while 15, 20, 25, or 30 years ago cast iron boilers were the exception in the heating business, to-day I think I can safely say that in American practice 80 per cent. of the boilers that are used for house heating or building heating purposes, are cast iron sectional boilers, and they do not confine them to small buildings. Some manufacturers that I am acquainted with sell largely boilers that will carry anywhere from 2,000 to 5,000 square feet of direct radiation in a single boiler, and they put them in office buildings in New York City that are 8, 9, 10, and 12 stories in height—not in a single instance, but in dozens of instances—and without any of the bad effects that Mr. Cary has mentioned here to-day. They do not go to pieces, they give satisfactory results, and they have that additional advantage over wrought iron or steel of not going to pieces during the summer months. I have seen the very best types of wrought iron construction, and latterly steel—they thought that wrought iron was better than steel, and I think it is—but I have seen the very best wrought iron constructions in use 6 years, that while originally the shell was ¼ inch to ⅜ inch thick, it became as thin as paper inside of 6 years. I have seen cast iron sectional boilers in use in this country continuously for 30 years, and to-day, to all appearances, they are as good as the original castings when they were first put in. There has been really no apparent wear on them, possibly a little scaling off. I know of instances in New York City and Brooklyn where cast iron sectional boilers are to-day in use that were made over 30 years ago, and they have not gone to pieces. They are still doing good, satisfactory work, almost as good as when they were first put in. Cast iron sectional steam boilers are used for heating this building, and they are also used for heating the office building of the largest manufacturers of wrought iron and steel water-tube boilers in the world.

Mr. Kent: The discussion of the paper mainly refers to boilers. A more important feature in the paper is the general condemnation of the whole American system, of the radiating system, in this paragraph: "We see that the gravity system

with a closed cycle offers many objections; or, at least, many difficulties, which the science of the engineer is often powerless to overcome." Then he presents this French system to overcome the difficulties. As Mr. Paul has said, we had the Tudor system fifteen years ago, and I think there is no heating engineer in America to-day who would adopt the French system. The American system has been developed during forty years of very large practice, while to-day the whole cost of all the heating done in France, as stated in the paper, is only 10,000,000 francs per year—$2,000,000. I suppose there is as much as that done in New York City.

Mr. Paul: Half a dozen concerns do that at least.

Mr. Kent: In this country we are doing probably more steam heating than all the rest of the world put together, and while we are exceedingly obliged to this gentleman for presenting this valuable historical paper to be put on record, there should not be an impression made that any American engineer believes that this system is better than ours. It is simply impossible that any American engineer should adopt the French system. The American system is the one that must be adopted in France if they want to perfect their steam heating. I feel so grateful to this French engineer for contributing this paper to our Transactions, that I should not want to hurt his feelings or the feelings of French engineers in the slightest degree. At the same time I should not like a paper to go on record condemning the American system without explanation.

Secretary Mackay: In manufacturing cast iron sectional boilers, there is a good deal of machine work. It is costly, and it would be unnecessary to waste machine work on defective castings. The first test, which is a very high one compared to the pressure the boiler is to operate at, is made largely to find imperfections, such as chilled iron not knitting together at certain points, or thin iron, blow-holes, and everything of that sort. Before it is subjected to the pressure test the casting is cleaned thoroughly inside and out, removing as much as possible of the sand. But it would be unnecessary or foolish to put a great deal of labor or machine work on a casting and afterwards find that it was defective. The second test, of 80 to 100 pounds, while it is made largely, as I said, to determine the tightness of the joints—you cannot put a pressure

on the joints without putting it on the casting—in putting it on the casting you develop any defect which did not originally appear. It was there and did not appear, and was perhaps filled with sand. But a pressure of 80 to 100 pounds, which is the practice of the cast iron boiler makers of to-day who make castings of such a type as will stand it, will give you a test on the casting a second time, for the handling and the machine work on the casting will loosen up any sand holes or things of that sort in the casting. The second test, as I said, was more to test the joint than the casting. The boilers I have described are very rarely subjected to a greater pressure than 30 pounds, while the average test is 80 to 100 pounds.

The Chairman: I should like to say that I do not take it that Mr. Mackay raised a point of order on that subject. If he had I should rather have to decide it against him as I have interpreted the paper. I interpreted it to say that the first-class engineers of this country who installed cast iron sectional boilers were rated as second-class engineers in France, and that was why I allowed the discussion to proceed. I did not understand that Mr. Mackay raised a point of order on that subject, and I think it was rightly before the house for discussion on the lines on which it was discussed.

Professor Kinealy: I want to say a word in regard to the automatic apparatus which has been condemned. Of course, we can make no piece of apparatus so good that it will run itself always, and an automatic feed-water supply, or an automatic apparatus for closing the damper in a pipe—any automatic apparatus, in fact—must be looked after. The reason that they give trouble is because in many instances they are looked after either by women or by a man who will come in the morning to take ashes, and fire up, and then go away and not see the apparatus again until night. That man may be attending to a furnace or hot-water boiler in this way for a month, then there may be a new man. I do not think that under such circumstances we ought to condemn the apparatus. We should condemn, though, the people who use them, and do not use them properly.

Mr. Payne: The paper speaks of automatic apparatus for feeding the water to the boiler. Automatic apparatus is very frequently a necessary evil. But an automatic water feed for

a gravity system is an unnecessary evil. If it is a gravity job, the water is returning by gravity, and I think it is a very great mistake to add this unnecessary evil. I have installed them frequently on the requirements of architects. In one apparatus which we erected a short time ago we put in an automatic water feed, and we found that there was a slight leak in the valve, which was very difficult to overcome, and the water would gradually leak in until the boiler became filled. The janitor asked me how he could fix it. I said, "I will fix it for you in a minute." I closed the water supply to the water feeder. "Now," I said, "you just open this valve (the by pass) when you want any water." And he said, "That's just what I want." And I think that is the best way. Automatic air valves, of course, are a necessary evil in a steam plant, and they need adjusting, which is an unfortunate thing. A person who will get up an automatic air valve that does not need any adjustment, will have a fortune. But I think the automatic feed-water apparatus should be abandoned for gravity work.

Mr. Paul: The question of automatic air valves has been brought into this discussion. I think the automatic air valves are all right, and, although I do not manufacture them, I think it is proper to say that the reason of trouble with automatic air valves in a large percentage of cases is the reason spoken of in regard to the care of automatic appliances. When I came into the business of steam heating, I found the automatic air valve, and I found the necessity of it; I also found that it had to stand up under use and abuse that nothing in the way of air valves made up to within a short time ago was able to stand. We set an automatic air valve for two pounds pressure, and then we run the job at five pounds pressure. Now the heat of five pounds pressure will expand an automatic air valve more than two pounds pressure will; and when the pressure goes back to two pounds, we expect the automatic valve to close. It is expecting more than is possible for any automatic valve, as formerly constructed, to do. Within the last year or year and a half automatic air valves have been made that will stand any pressure, even up to 100 pounds, and in expansion will not destroy themselves, but will come back to their original point, so that the valve will close at the temperature originally set for. The trouble was that the valves were

made so that they expanded against the end of the valve plug and they crushed the plugs by their own expansion whenever the pressure was raised beyond the point at which they were set, and the consequence was the valve would not close a second time. Now valves are made in which no such crushing occurs, and they can therefore work perfectly.

Mr. Kent: In regard to the criticism in the paper concerning automatic water feeders for boilers, I would like to ask Mr. Cary if he cannot give us some information on that. He has had a good deal of experience with automatic feeders.

Mr. Cary: I have applied a number of automatic water-feeding devices to boilers, and my experience has been, generally speaking, that they will work well for a long time and give good satisfaction; then, all of a sudden, just when you feel that they are to be implicitly relied upon, they will cease to work, and sometimes at a very critical moment. There are a number of them on the market, and they seem to find plenty of purchasers, but I must confess that I am a little afraid of them.

If I could feel assured that they would always be under the constant care of a careful mechanic, who would take them apart at frequent regular intervals and keep them in excellent repair, I would not hesitate to put certain ones in the steam plants I install, but such care of boiler apparatus is seldom found.

LXXXII.

SOME NOTES ON CENTRAL STATION HEATING.

BY WILLIAM H. BRYAN.

(Member of the Society.)

A decade ago the electric lighting world was in the clutches of the "system" salesman. There was the arc light man, and the incandescent light man. The incandescent field was divided against itself as between direct and alternating currents. The man who put in an electric light plant in those days put in somebody's "system." The owner or the agent of the "system" took the entire contract—dynamos, switchboard, wiring, sockets, lamps, fixtures, meters, transformers, and everything. There was serious doubt as to whether one man's lamp would work at all with another man's dynamo.

No promoter of a system would admit for a moment that there was any merit in anybody else's system. His was the one and only way to do it. The others were simply charlatans, thinking only of the purchaser's money, and sure to involve him in all kinds of difficulties, of which lawsuits on patent infringements were the least. Slight as was the purchaser's knowledge of electricity, it often happened that the seller knew but little more.

All this has changed. The generation and distribution of electrical energy have been reduced to an exact science. The advantages of each character of service have been clearly defined, and are universally recognized. Each has its field wherein it is supreme. The "system" has disappeared. The purchaser's engineer studies the problem, and determines the method of electrical generation and distribution which will best suit the conditions in hand. He writes specifications, and gets bids from half a dozen manufacturers. In the end he will quite likely get his dynamos from one firm, his converters from another, his lamps from another, his meters from another, and let the contract for the installation, including pole lines and distribution system, to still another. He has analyzed each maker's apparatus, and has reason for believing that the final plant will

go together in ship-shape, and will give greater satisfaction than if purchased from any single manufacturer. Indeed, it is rare that one manufacturer makes the best of each of the individual units which enter into the construction of a modern electrical plant.

Central station heating seems to be in the throes of the "system" to-day. John Doe addresses a learned body upon his particular way of doing it. So elaborate is his system, and so fully has every detail been covered, that it seems to leave nothing to be desired. He admits, however, that it has been done in other ways, but they are not to be compared with his. Forthwith Richard Roe, who also has a "system," corrals a page or so of the technical press, to tell a waiting world that his is the one and only system. He, too, admits that others have done it differently, but in so doing they have only exposed their ignorance. Others shy their castors into the ring, and it is a merry squabble. John Smith has a way to do it, but he does not urge it upon the central electric station manager. He has reached the opinion that there is no help for the electric station man in exhaust heating, and he must work out his salvation in other ways. In his judgment the conditions under which the exhaust from central stations can be profitably used for heating are so rare that they may be dismissed from further consideration.

Now all this adds to the gayety of nations, but it does not help the investor or the engineer who is hunting for the best thing. Each system can point to successful plants, but in every case success has been reached by a long series of expensive experiments. It cannot be said in this field—any more than in any other—that no mistakes have been made.

Now it is not the purpose of this paper to decry or undervalue either the systems or their promoters. They have done a good work and are entitled to their reward. They were the pioneers, and have borne the brunt of the battle. They have had a wide and varied experience, and know what to do—as well as what not to do, a qualification of even greater value. Nor is the benefit of a single responsibility for equipment and results to be underestimated. But it would seem that the time is rapidly approaching when the installation of a complete "system" will be secondary to the intelligent design and selection of apparatus by unbiased experts of good technical training, sup-

plemented by broad practical experience. They may be expected to attack this problem from the elevated standpoint of impartiality, selecting for their client whatever is good in any particular system, but leaving themselves free to purchase such portions—whether large or minor—from other builders where a particular detail is of higher merit.

The success of the installations thus far made has in most cases been due to fortunate surroundings. Indeed, it is not to be denied that in many cases a system of entirely different character would have succeeded equally well. It is nevertheless true, that each way of doing it has its advantages, and also its disadvantages. Sometimes the conditions are so unfavorable for central station heating that no system could succeed. In other cases the conditions are peculiar, and can be met by one system better than another. A system which scores an unqualified success in one city, may fail and another succeed in a neighboring city where the conditions are different.

It is not too much to say that continued success hinges upon the proper selection of methods and means, and the detail design of the installation, coupled, of course, with intelligent and energetic business methods and technical judgment in the operation and management.

The above are the conclusions which resulted from a recent attempt to collect and digest the available literature and experience on the subject of central station heating. These investigations into the present state of the art had special reference to the use of exhaust steam from central electric plants. The lack of accurate and reliable data was surprising and disappointing. Much of the literature has been written from the standpoint of the promoter of a particular system, or by the user of a system who advocates it highly, but who, having had no experience with other systems, is not in a position to give an impartial verdict. There appear to be many faulty and misleading data at large. It seemed, therefore, that it might be of value to place on record some of the data collected—not with a view of presenting anything new or startling, but in the hope of bringing out additional facts, and of inviting discussion.

Heating from central plants is not new, although the subject has only recently begun to attract extended notice. Nevertheless, the outlook is one of great promise. It is, of course,

only feasible in cities of some magnitude, where large commercial buildings or residences are concentrated, and so located as to be readily reached from a central station. This is usually on the outskirts of the business section, where fuel and water are readily secured, and where ample room for growth is available.

Many methods of central station heating have been employed, but they have now been reduced to practically two—steam and hot water. Experiments have been made with hot air, gas, and electricity, but without marked success. Hot air has been carried to limited distances where groups of buildings are situated together, but the size of ducts necessary makes this system prohibitive over any extended area. It is feasible in isolated buildings, in connection with coils served by either steam or hot water from a central station. Indirect heating of this character is common, but the successful distribution of hot air itself is necessarily confined to a single building or group. The manufacture and distribution and use of gas and electricity for heating are both attended with so much apparatus, and with such large unavoidable first costs and losses in efficiency, as to be out of consideration for any extended use. Both have—and will continue to have—some limited application for peculiar and special purposes, but neither is a factor of importance in the problem of central station heating. Even electric railways, which are perhaps the largest producers of electricity, and which produce it at the lowest cost, are in many instances abandoning electric heating in their cars, while many central stations already sell their exhaust steam for heating, but make no effort to sell the electric current for that purpose.

Central station heating follows the same general laws which govern isolated installations. When the sale of steam is the main business of the plant, and there are no engines on which low back pressure must be carried, the steam pressure is high enough to force circulation to extreme distances, and in some cases even to run engines. Pressure reducers are supplied at the point of use to give the customer whatever indoor or secondary pressure he needs. Where part of the steam supply is from the exhaust of engines driving dynamos—as is often the case in modern plants—the pressure must be so low as not to interfere with the proper working of the engines. This necessitates larger mains, and is sometimes accompanied by difficulty

in securing prompt and effective circulation, particularly where the mains are long and not well designed or located. The branch pipe leads to the house mains identically as if supplied by a local boiler. The indoor distribution may be either one or two pipe, and needs no special design to fit it for central station work. It does not pay to bring back the returns to the station. The cost of the second pipe properly insulated, its rapid deterioration, and the frequent presence of oil or other foreign matter, has led to the abandonment of this practice. It is customary to install an "economizing" coil near the front of the house, over which external air is admitted, giving the necessary indirect heating and ventilation. The returns from the radiators pass through this coil, giving up practically what heat is left in them, and are then trapped to the sewer.

The main distribution system is of course always underground. The pipes must be large, and their temperature being high they must be thoroughly insulated with the best of material. It is also necessary to run a drain line of tile underneath each pipe line to prevent water from collecting and standing around the steam pipes. Suitable expansion joints, or "variators" are provided at frequent intervals; also man and hand holes for access to valves, joints, etc. Care must be taken in laying steam lines to prevent accumulations of water, all low points or pockets being drained and trapped to sewer. The steam system readily takes care of plants which have been installed to use hot water, as they have a surplus of radiating surface, and only a few very simple changes in the pipes are required.

Hot water systems are usually operated from central electric plants utilizing their exhaust. This has passed through closed exhaust heaters of large capacity, the outlet being to the atmosphere either direct or through a back-pressure valve. If the heaters are of ample capacity and properly arranged, there need be no back pressure. The water may be given any desired temperature up to 212 degrees Fahr. and is circulated by steam pumps. There is an outgoing and a return main, the distribution being what might be called multiple-series. At each building served a connection is taken from the supply main and serves the radiators, which are themselves in series or multiple-series. The returns are finally collected and go to the return main. There are a few instances of single pipe mains, the returns

going back to the same main, being diverted to the house by a shunt.

There are two methods of regulation. In some cases the water is sent out at a constant temperature, and each individual user controls his radiators just as he would with his own plant, turning them on and off at will; or he may regulate them automatically by thermostats; or the entire plant may be handled by thermostats. In such an installation the speed of the pump varies, being controlled either automatically by a thermostat, or by an attendant who judges of the heat requirements by the temperature of the return water. In other installations the pump is operated at a fixed speed, the temperature of the water being changed with the weather. By adjusting the radiator valves of such installations the proper amount of water can be kept circulating through them, the customer thus being relieved of all care in the matter of regulation. The station attendant keeps close watch of an external thermometer, and raises or lowers the temperature of the outgoing water to correspond.

When the exhaust is insufficient, live steam may be admitted to the heaters, just as it would be turned into the mains with the steam system. In either case, separate boilers may be fired, discharging steam or hot water directly into the mains without the intervention of engines or heaters, a practice often followed.

In some few cases the attempt has been made to store surplus exhaust or its heat, at the time of maximum electric load, for use at times of maximum heat demand, but this involves considerable investment of capital and space, as well as a number of difficult mechanical problems. This is a feature of the work which will repay further study.

For some time efforts have been made to interest owners of electric plants in heating, with a view of utilizing their exhaust steam. Nearly all small plants—and many of medium size, as well as a few large ones—are non-condensing. On its face the proposition is attractive. Here is a waste, or by-product, which can apparently be sold at practically the full value of the original steam. The demand for heat comes at the time of year when there is the maximum demand for light, and when the greatest amount of coal is being burned anyway. Another attractive argument is that the thermal efficiency of the ordinary engine is only about 10 per cent., rising in rare cases of exceptional im-

portance to 15 per cent. The remaining 85 per cent. to 90 per cent. can be saved and made revenue earning by turning the exhaust into heating mains. The companies already sustain business relations with their prospective heat customers, and many would be glad to contract with them for heating. In many cases additional contracts for light and power can be secured which are not now available, as the owner must run his boiler for heating anyway.

It would appear that the scheme ought to present no particular complications in view of the universal use of exhaust steam for heating in isolated commercial buildings. In studying the subject a little closer, however, some difficulties arise. In the first place, the use of exhaust steam has usually necessitated a considerable back pressure on the engines, thus straining them beyond what they were built for, and reducing both their capacity and efficiency. Surprising as it may seem, it has been seriously claimed that not only is back pressure not objectionable, but that it is, on the whole, rather a good thing for an engine, as forcing it to buckle down to its work closely and restraining its desire to shirk. The testimony of builders and operators of engines is cited to show that no diminution either in capacity or efficiency is noticeable.

The fallacy of these statements has been amply demonstrated by Mr. Albert Spies and Professor Whitham, in communications to "Heating and Ventilation," for March and August, 1894, showing that the water rate per indicated horse-power hour increases fast with high back pressures. This would not be material if the demand for heat always equalled or exceeded that available from the exhaust. But this is frequently not the case, as is shown by Figs. 3 and 4. The situation is improved by separating the exhaust into two mains, and allowing only a portion of the engines to exhaust into the heating mains when the demand for heat is small. The exhaust from the remaining engines then goes direct to the atmosphere, without back pressure, or to the condenser.

It has also been stated that the effects of back pressure may be overcome by simply carrying a little higher boiler pressure. As even in simple engines the initial pressure is four or five times the mean effective, the boiler pressure would have to be raised by more than the amount of the back pressure. As most

plants are already working close to their safe limit of boiler pressure this is rarely feasible.

How much heating patronage may an electric station properly take on? Let us assume a station having 1,000 horse-power of rated boiler capacity, divided into, say five 200 horse-power units. One of these should be kept in reserve for cleaning and repairs. The remaining four boilers, rated at 800 horse-power, if of good modern design, will easily develop during the hours of maximum load, one-third additional, a total of 1,067 horse-power, equivalent, let us say, to the evaporation of 32,000 pounds of water per hour. Allowing 5 per cent. for leakage and condensation losses through pipe system, engines, etc., and 15 per cent. for heating feed water, a maximum of 25,600 pounds per hour of exhaust steam is available to be sent out into the heating mains. The loss due to condensation and leakage in the mains cannot be definitely determined, and is, in fact, variable, not only in different plants but in the same plant. It probably varies from 5 per cent. upward, but under no conditions should it exceed 25 per cent. On the latter basis 19,200 pounds of steam is available per hour for use in buildings. The condensation per square foot of average ordinary direct radiating surface, under the most severe conditions, runs from .25 to .3 pounds per hour. On the basis of the latter figure, the steam available will supply continuously 64,000 square feet of radiating surface.

In heating, however, there is a load factor, just as there is in light and power. Experience has shown that no matter how many lights, motors, or radiators may be connected to the station, they are never all on at once. Many stores, theatres, offices, rooms, and sometimes entire residences, are only in partial use, and are, perhaps, entirely out of use at certain times. I have been unable to secure any exact data as to what this load factor actually is for heating. It depends, of course, upon the system of service, and also on the rates, and whether flat or by meter. It would appear conservative, however, to put the average figure at 80 per cent., on which basis it would be safe for the station under discussion to contract to serve 80,000 square feet of ordinary direct radiating surface, or its equivalent. All of this is based on the assumption that the plant is primarily an electric station, and that it has not as yet been thought wise to install additional boilers or apparatus for the sole purpose of

supplying heat. This may come later, but the attitude of the average plant to-day is that exhaust steam, and not electricity, shall be the by-product, the object being to increase the efficiency of the existing plant and force of operatives.

The above computations indicate that 80 square feet of radiating surface may be connected for each rated boiler power of plant, assuming the usual boiler reserve of 20 per cent., and

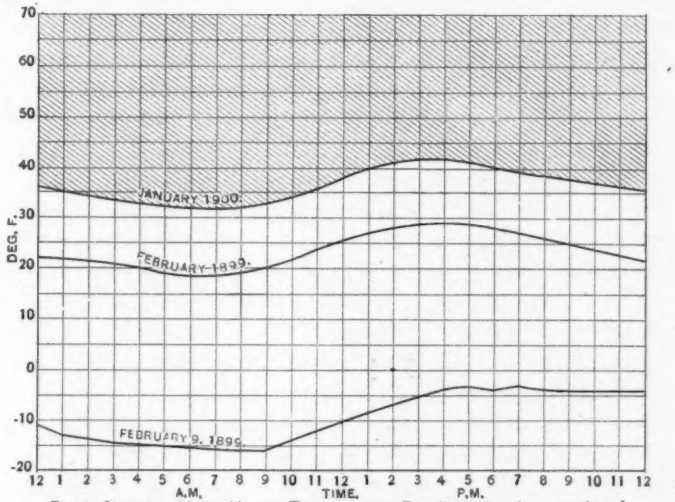


Fig. 1. Showing Mean Hourly Temperature Readings for the months of January 1900 and February 1899, also for the coldest day of the year 1899. From the Records of the U.S. Weather Bureau, St. Louis, Mo. The hatched area indicates the heat which must be supplied to maintain the usual indoor temperature of 70° F.

ability to overwork of 33 per cent. If we assume that the radiating surface throughout the city averages one square foot to 75 cubic feet of space heated, each boiler horse-power will take care of 6,000 cubic feet.

The above figures are conservative. Under favorable conditions it would often be safe to take on 100 square feet radiation for each boiler horse-power, or 7,500 cubic feet of space. For severe conditions, however, the last-named figures are too high.

Most electric stations keep records from which curves or charts are plotted, showing the output throughout the 24 hours. No such charts seem to have been kept by heating

stations. The data ought to be easily secured by simply noting the temperature or speed of pump in the water system; and by hourly, or half-hourly, readings of counters on boiler feed pumps in live-steam stations. The demand for heat must, of course, closely follow the fluctuations of external temperature. I have secured from the St. Louis office of the United States Weather Bureau some interesting hourly temperature readings. Fig. 1 gives the average hourly temperatures in St. Louis, Mo., for January, 1900, which is, perhaps, a fair average winter month. Fig. 1 also shows the curve for February, 1899, one of the coldest months. Also the readings for the coldest day of that month, which was, in fact, the coldest day of the year. The cross-sectioned area between the average line and 70 degrees represents the heat which must be supplied to maintain the usual indoor temperature. This is a maximum between 6 A.M. and 8 A.M. and a minimum about 4 P.M. The range, however, is smaller than would ordinarily be assumed. In most heating systems, however, particularly those not regulated automatically or from the station, the demand for heat would not follow the curve exactly, but would lag behind it, an appreciable interval of time being necessary to make the external changes of temperature felt indoors. Furthermore, some normal deviations are to be expected. The most important of these is probably the turning off of heat in unoccupied buildings at night, and the shutting down of the heat in residences at bedtime. These would all be cut in again early next morning. This effect undoubtedly exists, but to what extent is difficult to determine.

In Fig. 2, the curve showing the heat required to maintain 70 degrees has been inverted, and a correction intended to indicate what the actual demand for heat will probably be, has been made. In Fig. 3 the revised curve has been plotted upon an average load chart of an electric light station, and in Fig. 4, upon an average load chart of an electric railway station. In both cases the maximum output of steam for heating is made the same as the existing maximum for electric service. It is assumed that enough steam heating has been taken on to load the plant to this point, and that the boilers reach their maximum output twice daily, once for heating and once for light or power.

Fig. 3 shows that for five-sixths of the time the demand for heat exceeds the exhaust available, and that live steam must be used

and additional coal burned for heating. From one-third to one-half the steam required during this period can be supplied by the exhaust, and the economy of the engine is of minor importance. Back pressure during this period is not objectionable, as the reduction of capacity, if noticeable, can be met by putting in

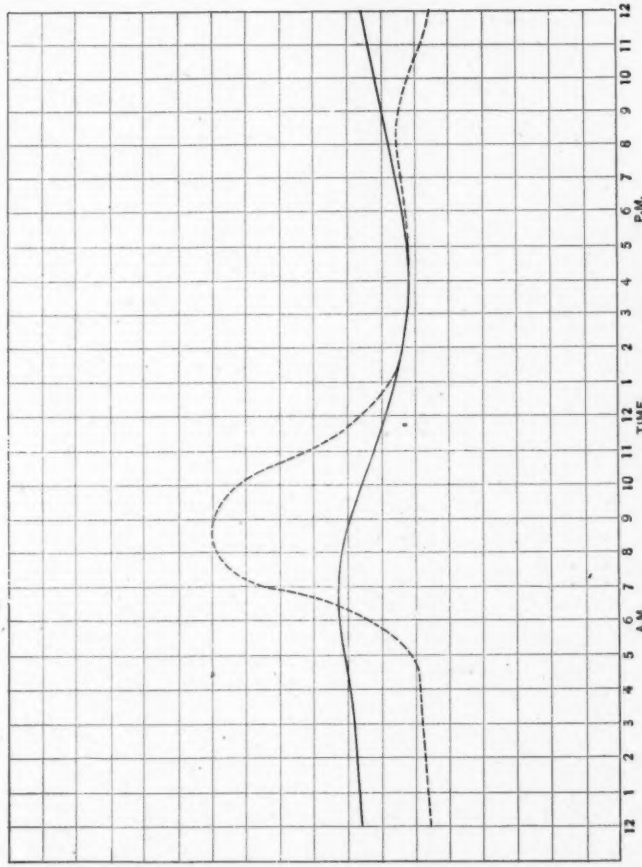


Fig. 2. Curve of Hourly Heat Demand with Corrections Indicating Probable Demand on Station.

more engines. For the remaining 15 to 20 per cent. of the time the exhaust exceeds the demand, and one-third to half of it goes to waste. The losses in engine capacity and efficiency from back pressure during this period are serious. It is clear that the crying need of this service now is a satisfactory apparatus

by which the exhaust now wasted during the "peak" of the electric load, can be made available during the hours when there is a deficiency of exhaust.

Fig. 4 shows that the heat demand corresponds far better with the load of an electric railway, which indicates that exhaust heating is a better proposition for railways than for lighting plants.

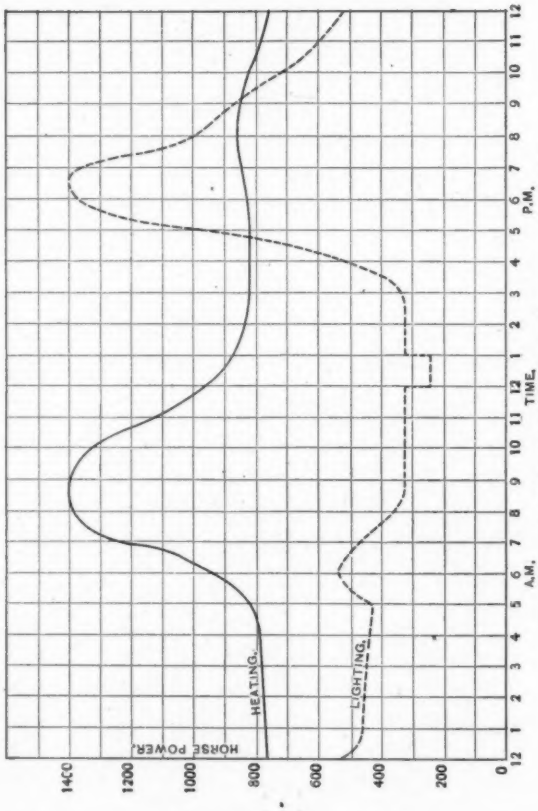


Fig. 3. Curve of Hourly Heat Demand, compared with the Output of an Average Electric Lighting Station, both reduced to Boiler Horse Power.

Fig. 3 indicates the difficulty under which the average electric light station labors. No scheme of electrical storage having yet been found sufficiently cheap and efficient to come into general use, electric stations must generate current exactly as their customers use it. For a few hours each day, therefore, the plant works at its maximum, but for over 80 per cent. of the time a

large portion of the equipment is idle. This adds greatly to the cost of generating electricity. Station managers are always on the lookout for means of making the work of the station more uniform, and of utilizing their station, equipment, and force,

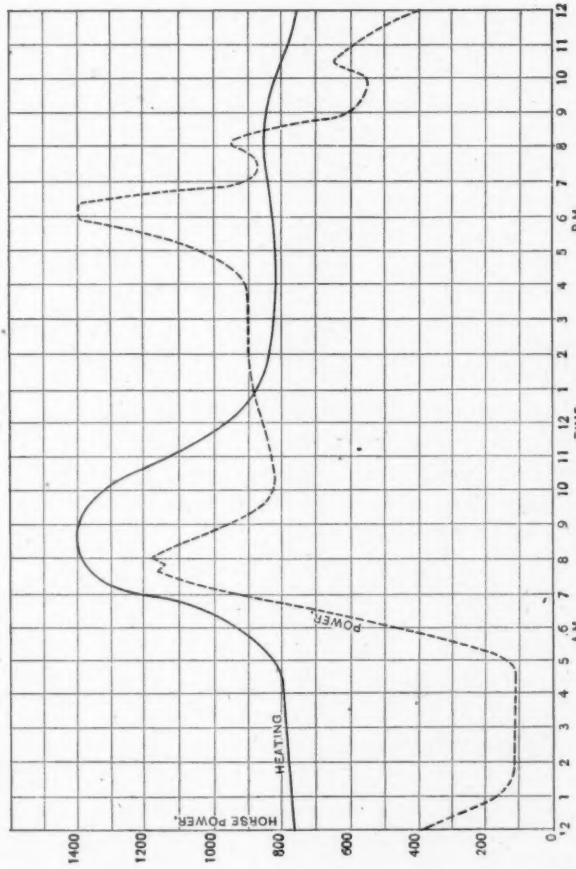


Fig. 4. Curve of Hourly Heat Demand, compared with the Output of an average Electric Railway Station, Both reduced to Boiler Horse Power.

more hours each day. Central station heating offers advantages in this direction, as the entire boiler equipment and force can be utilized to advantage when the electric load is small by supplying directly from the boilers whatever deficiency there is in the exhaust for heating.

Is it possible to weigh the exaggerated and conflicting claims

of the advocates of the steam and hot water systems with a view of reaching an unbiased conclusion as to the particular features in which one or the other appears preferable? While it cannot be hoped that such a conclusion will meet the approval of either party, the interests of sound engineering would appear to make the attempt worth while. It is assumed, to begin with, that each installation is to be put in in good faith, and that the material and workmanship is to be first class in both cases.

The following points of advantage appear to be with the steam system:

1. Simplicity. There being a single pipe line and no pumps being necessary.

2. The equipment or plant appears to be more durable. The life of underground pipe lines carrying steam has been shown to be much greater than those carrying hot water.

3. The investment in radiators for utilizing the heating service is less by the usual ratio between steam and hot water radiators.

4. The system will satisfactorily serve buildings which have been equipped for either steam or hot water heating. A hot water plant cannot handle a building equipped for steam heat, except at considerable expense for reconstruction.

5. Less pressure being carried there will be fewer leaks, and less liability to damage in case of accident.

6. Leaks may be repaired, valves packed, etc., without the necessity of shutting off the entire house.

7. The steam people have whatever advantage results from long experience in the heating business, and the construction and operation of many plants under wide ranges of conditions.

The following advantages appear to be with the hot water method:

1. Cheapness of installation, although this is to some extent off-set by the necessity for a return line. The low temperature makes it unnecessary to provide as many expansion joints, or to use as high a grade of insulating material, while the fact that the medium is water renders sub-drainage unnecessary.

2. Milder temperature, which is preferable in radiators, hot water now being used almost exclusively for residences. The low temperature also reduces the radiation losses, which are proportional to the differences of temperature.

3. There being no waste to sewer, either at low points or at discharge from residences, there is no loss of water or heat at these points.

4. Water appears to adapt itself readily to regulation, either automatically or by an attendant at the station.

5. Water appears to lend itself better to heat storage, which, as is shown in Fig. 3, would improve the economy of the station.

6. Operation without back pressure. While this is of less importance than would appear at first glance, it nevertheless should have the earnest attention of the steam advocates.

7. There are no offensive odors from the air valves or stuffing boxes of radiators.

8. It would appear to be easier to discover and locate serious losses of water or heat.

There appears to be no choice between the two systems in the matter of power required to circulate the heating medium. Fig. 3 shows that for five-sixths of the time the demand for heat exceeds the exhaust available, so that neither the back pressure on the engine nor the running of a special pump would affect the total steam to be generated, as there is always a deficiency to be made up direct from the boilers. Both systems are wasteful in this respect during the peak hours. If, by the adoption of modern methods, steam can be distributed without back pressure, the system will then have an important advantage over water.

It would appear possible to meter both systems. The use of steam could be measured either directly by steam meters or by hot water meters on the returns. In those water systems carrying constant temperature and changing the speed of pump to suit the demand, the water could also be metered. This could not be done, however, where the speed of pumping is constant and the temperature is varied.

It would be risky to hazard a recommendation as to choice of system, as every proposed location would vary in its conditions and requirements. Some general observations may be in order, however.

If the capital available is limited, and the most ground must be covered for the money, the water system would probably be selected. If the city to be served is hilly, or has many tall buildings to be served, the water system would appear to be undesirable on account of the high pressures which would have to be

carried in order to reach the high buildings or districts, this pressure being likely to cause trouble in the low districts. If a preliminary canvass of the city shows that a majority of the buildings to be connected are already equipped for steam heat the steam system should be adopted, while a majority of hot-water plants would "indicate" that system.

As more steam is required to heat a building than to light it, a central plant can secure a sufficiently large heating patronage much closer the station than it can its light patronage. If the buildings to be heated are close at hand, so that the investment in expensive mains can be kept down, the advantages would be with the steam proposition. On the other hand, if considerable area is to be covered, considerations of first cost might limit the system to water. A point which appears to hamper the water system now is the uncertainty as to the life of underground pipe lines and their insulating conduits. Until the system has been in service for long periods of years, under all sorts of conditions of soil and climate, there will continue to be some hesitancy on the part of capital.

Not all electric stations can enter the heating field with profit. Many are located too far from the district to be heated. Cheap fuel and water, and ample room for present arrangement and for growth, usually determine the location of plant. In other cases the topography is such as to make it an attractive proposition for neither steam nor hot water. In some places the price of fuel is low, and in others the people have not been educated up to the point of appreciating artificial heat under modern methods, and could not be induced to pay a profitable price for it.

The rates charged for heating in different cities and under different conditions vary considerably. The conditions controlling the price are the cost of fuel, the distance the service is carried, range of external temperature, and number of months of service. In most cases the charge is for a season's service, and is based either upon the square foot of radiation, or 1,000 feet of space heated. The rates for hot water vary between 12½ cents and 20 cents per square foot of radiation. For steam, the range is from 15 cents to 30 cents, although a rate of 50 cents is reported from Seattle. The charges run from $2.50 to $5.00 per 1,000 cubic feet of space heated, which, of course, is independent of whether steam or water is used. A slightly higher

charge is made for indirect radiation. When steam is sold by meter, the unit is the kal, which is the amount of heat required to evaporate one pound of water. This charge varies from 45 cents to 80 cents per 1,000 kals, depending upon the customer's requirements.

Experience in hot-water plants indicates an average consumption of coarse slack of about 55 pounds per square foot radiating surface per season. If we assume that one square foot of surface heats 50 cubic feet, then 1,100 pounds of coal will heat 1,000 cubic feet of space; or with slightly better coal it may be said that one pound per season will heat one cubic foot of space.

For some years it has been the almost invariable practice in isolated steam-heating plants to use one of the vacuum systems of handling air and returns. Heating in modern buildings is now done without back pressure on the engines. The use of such systems is entirely practicable in connection with central heating plants, and there have been some successful installations of this character. Their use, of course, adds somewhat to the complications, and materially to the first cost. The recently developed vacuum air valves—which prevent the return of air into radiators—seem well adapted to this purpose at small cost, in connection with steam systems. There seems to have been no such application of them, however, and some doubt exists as to whether they can be kept tight. Their use would necessitate carrying a pressure of several pounds on the system for a few minutes every day to blow the air out of the radiators, but this could be done at a time when live steam was being used anyway. Traps of special construction would also be necessary to discharge the return into the sewer when there is no pressure in the system, and without admitting air.

Some revenue may be secured from the heating of hot water tanks, for baths, laundries, kitchens, etc. This service, however, is usually desired for the entire year, and it is only in rare instances that sufficient revenue can be secured to justify carrying heat on the mains during the summer months.

In Fig. 3 the curve represents the maximum output of both light and heat. In mild weather the heat curve would have the same general characteristics, but the output would be much less, and for considerable periods in the fall and spring, it might even drop to a point where the demand was equal to or less than the

exhaust during periods outside of the peak. At such times no steam would be used direct from the boilers, and absence of back pressure on the engines would be of importance. This would also hold true for a considerable period after a new company enters the heating business, as it would require some time to secure enough contracts to utilize the full capacity of the boiler plant. During all these periods of service the exhaust might be ample.

The steam people claim that the demand for heat will soon reach a point where in cold weather it will utilize all the exhaust available, even at the peak of the electric load. If this is a fact, then Fig. 3 shows that the demand will be some 50 per cent. greater between 5 A.M. and 7 A.M. If the electric plant is worked to the limit of its capacity at the peak, as has been assumed, it would then be necessary to install additional boilers to take care of the early morning heating load. This changes the entire aspect of the problem and makes the station one which produces heat and sells its electricity as a by-product, instead of an electric station selling heat as a by-product. Such an installation may often be justified by circumstances, but it is foreign to the present discussion, which presupposes no additional investment at the station on account of entering the heating field.

It is true that steam at atmospheric pressure is not quite as effective as steam at 5 to 10 pounds pressure. A good vacuum system of air removal would in most cases make the radiating service sufficiently more effective to overcome this difficulty. But as the maximum demand for heat comes at an hour when live steam must be employed anyway, there is no objection to carrying a somewhat higher pressure for short periods to overcome any deficiencies which might be found.

What is the best thing for a central station to do with its exhaust—put in condensing apparatus, and increase the capacity and efficiency of its engines 20 to 25 per cent.; or to run non-condensing, and sell the exhaust for heating?

Many points must be considered in answering this question, such as cost of fuel, cost of plant and water for condensing, capacity of engines, and work required of them, hours of loading, amount of the heating that can be secured, etc. Condensing increases the value of the steam only 20 to 25 per cent. as a maximum, while the sale of the exhaust for heating should bring

75 to 80 per cent. of its original value. It is evident, therefore, that when the exhaust can be sold for heating at fair rates and without too large an investment in plant, it is more profitable to do this than to condense. If the amount and duration of the load and the price of fuel are such as to justify condensing apparatus, it could be kept in operation throughout the non-heating season, and also during the heating season on those units from which the exhaust was not needed for heating, particularly during the peak of the load.

A concise statement of the advantages to the customer, the electric plant, and the general public, resulting from the installation of a central heating plant, may be worth making. The customer saves the expense of coal and ash handling, with their unavoidable accompaniments of dirt, dust, smoke, and soot. The saving of labor is a considerable item, particularly in large plants. The heat supply is regular, continuous, and unlimited, and is available throughout the entire night and on Sundays and holidays. The building need never become cool. The heat is capable of regulation and adjustment with fluctuations in the external temperature. Valuable space in basements and cellars is saved, there being no longer any necessity for boilers or coal storage. It is possible to have a cool cellar, which is often an advantage where it is desired to keep vegetables or provisions. Insurance rates, too, are less where there is no fire in the building.

The service demanded of the ordinary heating boiler is so variable, and it has so little skilled attention, that its thermal efficiency is very low, rarely exceeding 50 per cent., and averaging probably not over 35 per cent. Furthermore, in order to keep fire over night, and to avoid making a smoke nuisance, it is almost imperative in many ordinary heating plants to burn the most expensive grade of the very best coal. In large St. Louis residences, for instance, anthracite lump of 13,000 British thermal units per pound, costing $7.00 to $8.00 per ton, is burned, with an average efficiency of 35 per cent. Under the boilers of a central heating plant, slack coal or screenings, costing $1.00 per ton and having a calorific value of 10,000 British thermal units, would be burned, with an average efficiency of 60 per cent. The fuel cost of the isolated plant under such conditions is ten or twelve times as great as that of the central station.

The heating business has attractions to central electric stations aside from the mere profit which the books may show. It adds to the permanency and security of the company's business, and, therefore, places the capital invested upon a more attractive footing. It often enables the company to secure contracts for electrical service which it would not otherwise get. The most difficult condition which the salesman of electric light and power meets, is where the owner must retain and operate a boiler plant to heat his building. He argues that the additional expense and inconvenience of operating engines and dynamos for light, elevator and power service, are not great. When a central station can supply heat as well as light and power, it is in a position to meet this argument and permit the customer to remove his boilers and utilize the space for other purposes, besides doing away with the many nuisances connected with the operation of his own plant, particularly through the summer.

There are advantages to the general public in central station heating in the concentration of the plant in an out-of-the-way location, in the reduction of the number of coal and ash teams on the streets, and the removal of the smoke nuisance, besides the direct benefits obtained by those who make connection with the plant.

There are many incidental advantages connected with the use of central station heating beyond the mere saving of fuel. This service—while in many cases a necessity—is in some instances a luxury, and it should command a price accordingly. It is worth much more to a customer than the mere amount he saves, and he should be willing, therefore, to pay the central station a rate which will enable it to earn a fair return on the necessary investment.

While these notes indicate that there are many cases where central station heating would not be profitable to electric plants, it is nevertheless a fact that many cases exist where a small investment in this direction can be made to yield handsome returns. Just what can be done in any particular case, and whether steam or hot water is preferable, and what the details shall be, can only be determined by an intelligent and exhaustive study covering all local conditions. It goes without saying that such a study should be made by disinterested and competent persons who have no interest in the matter further than to dis-

cover and reveal to their employers all the facts bearing on the case.

DISCUSSION.

Professor Carpenter: I think we are very much obliged indeed to Mr. Bryan for this excellent and exhaustive paper on the subject. It seems to me that it covers the ground better than any paper that I have ever heard. He brings out in the paper two or three things which I think are of considerable importance in connection with the system of heating discussed. One is relative to the very short life of the return pipes. I have had considerable experience in that line, and I have been troubled by the fact that steel or wrought iron pipes under such conditions seem to last a very short time. My experience has been, however, with that form of central station heating where we circulate exhaust steam rather than hot water. In that case we find that the life of the return pipes is very short; thus, for instance, in a line at Cornell University, which is something over 2,000 feet in length and possibly contains something over 100 lengths of pipe, we have had to replace on an average, since its first construction, from three to four lengths, which would be equivalent to 3 or 4 per cent. of the pipe; that is, the pipes fail by the formation of small holes, which we term "pin-holes." The condensed steam seems to act on certain portions of the pipe and to form these holes; we do not seem to be able to get any grade of pipe which remedies this action for any great length of time. This is a very serious matter, because it means not only the expense necessary for the repair of the pipe, but it means the trouble and interruption of the heating service, which incidentally affects us much more than the expense of repairs. We have also had occasion to notice the short life of return pipes, where they contain a considerable amount of water, in one or two of our large buildings; in one building we are particularly troubled with the short life of return and steam pipes. Perhaps pipes of wrought iron may have an average life of ten years; but new pipes which have been in only a few months frequently give out; whether it is due to some peculiar condition or property with respect to the action of the water on the pipe is something that we have not as yet been able to solve. But it certainly is a serious question, and

it leads me to believe that the proper kind of pipe for this work is cast iron, and I firmly believe that in a short time—it may be ten or it may be fifteen years—we shall be following the example of the water-works engineers, and using for the principal pipes of our heating system cast iron instead of wrought iron or steel.

There was one other point which I also wished to refer to, and that is in regard to the low efficiency of heating boilers. My experience has not been quite the same as Mr. Bryan's in this respect. He states that the heating boilers have a very low efficiency; that may possibly be true in some cases, but I have had an opportunity of testing three or four different boilers at different times, and with the low rates of combustion common to those boilers I have invariably obtained a very high efficiency. Now, I do not know how far we could extend the results of these tests to practical operation. It is possible that in making my test I gave boilers more favorable conditions than would be found in ordinary buildings, but I tried to test them under just the conditions of ordinary use, and the results were certainly very favorable to the boiler. I obtained a much higher efficiency than I expected and about twice what Mr. Bryan states in his paper as the common efficiency. If Mr. Bryan has tests of such boilers, I think it would be very interesting to have them placed on record. It may be that when handled badly the results may be poor, but I think very frequently at least the boiler is quite efficient.

Mr. Smith: Mr. Chairman, one of our visitors wishes to ask Professor Carpenter how he would connect those cast iron pipes.

Professor Carpenter: That is one of the things I have considered without arriving at a solution, and I suppose that it is one of the difficult things to do; possibly the scheme I have in mind would not work at all, but I have considered the method which the Green Economizer people have used so successfully in their economizer. It requires a tapering joint and that both the internal and external parts be turned; these are drawn together by external flanges. That method certainly works in the Green Economizer, under very high pressure, and the joint so made stands. Some of those economizers have been used for over twenty years without any sign of failing.

Professor Kinealy: I should like to ask Professor Carpenter some questions in regard to the giving way of the pipes. Did the pitting or rusting begin on the inside and work towards the outside, or was it from the outside towards the inside?

Professor Carpenter: I would not say that the pitting was universally from the inside out, but it was generally that way. In fact, in every case I closely examined it had been from the inside out, and not from the outside in. But there have been so many cases recently that I have not even stopped to look at them. I had a man repairing a joint in one pipe last week, and before he got through there was another one open in the adjoining length.

Professor Kinealy: The reason I asked the question is that we have in St. Louis some buildings that are heated from a central station or central plant, and after a life of from ten to thirteen years the steam pipes begin to give out; but in all cases —and I have examined some very carefully—it appears that the short life was due to rusting which began on the outside, on the thread of the pipe, close to the coupling, and the pipe was gradually rusted away. The rust would form on the outside, and the expansion and contraction of the pipe would apparently break it off, until finally there was a very thin shell, and then the steam would blow through. I could find no rusting from the inside. These pipes were well drained, there was very little water in them. That may have made a difference.

Professor Carpenter: I was just going to explain in reference to Professor Kinealy's inquiry that the particular pipes that I was speaking about just this moment were in my own laboratory, where we happened to have four such breaks last week, and it has invariably occurred in the middle of the pipe; there was not a single one in the joint. The pipes were, perhaps, not well drained; perhaps they had pitch enough, but our steam comes a long way and it is very wet. I would not expect any such results with dry steam. The fitter who has charge of the repairs throughout the whole university tells me that he has been troubled very much in the university building for the past two winters with quite a number of makes of cast iron radiators by the wrought iron nipples giving out in the threads used to connect the sections, just as the Professor has stated; but in our own particular building that trouble has not happened.

Mr. Harvey: In connection with the return pipe in my experience, I used to find a great deal of difficulty in all low-pressure jobs where the water was let out of the returns during the summer time, and where the air could act on the inside of the pipes. Then I have put in new pipes, had the boiler kept full of water during the entire time when it was not in use, flooding all the pipes. I have found by actual test (I notice that Professor Carpenter has also found the same difficulty) there are some places, perhaps within a short distance of each other, that will act in the way that he describes. I have often thought there must be some difference in the purity of the material of which the pipe is made. For instance, we find in boilers where the water of condensation is continually returned to those boilers by gravitation or otherwise, the pitting takes place in the boiler tubes. In some cases I have put new tubes into boilers, and they did not last more than three years; while, again, a tube in another boiler used in the same manner would last ten years under similar circumstances. The conclusion that I have come to is simply that there must be a certain affinity of the water eating certain qualities of the iron more than others. That is about the only way that I can account for it happening; because it seemed strange that this would occur in one place and not in another, under the same circumstances.

Mr. Payne: Mr. Chairman, I have lately had the opportunity of observing the advantages as well as the disadvantages of using cast iron mains for steam purposes. I overhauled a plant two weeks ago where there had been cast iron mains in use for fifteen years for conveying steam, carried in a brick trench. When they were taken out they were apparently as good as the day they were put in, with the exception of the joints. The joints were made by calking—using rope and then iron borings moistened with water—but, on removing the pipe, I found almost all the hubs split; why I don't know. When we use it for hot water work it does not split. But I have noticed quite frequently of late that cast iron pipes that have been in use for steam a number of years split at the hubs. In this case, in a run of pipe 150 feet long, there were about ten or twelve lengths in which the hubs were split. The lengths are about 9 feet long. But apart from this, the pipes were perfect. I replaced them with wrought iron pipe, because of this difficulty with

the joints. Of course, it would be rather expensive work to use the kind of joint Professor Carpenter speaks of in this class of work; but evidently, apart from the matter of joints, cast iron pipe for steam mains is desirable on account of its lasting properties.

I might also mention, in regard to the efficiency of the heating boilers that Mr. Carpenter has mentioned, that in some tests which I have had the privilege of assisting in, we found that the efficiency has run from 65 to 70 per cent., running them as nearly as possible under the conditions which we would expect to find in heating a residence. Of course, as he says, the boilers were clean, which would have a tendency to increase their efficiency.

There is one other point in the paper, in which it mentions the vacuum air valves, with which I have been having some experience of late. I put in a plant last year where we used long coils of 1¼-inch pipe, in which it was desirable to close down the steam in the morning, as a rule, and not turn it on again until the afternoon. Of course, we all know the difficulty there is in expelling the air from the circulation quickly. I put in these vacuum valves as a test. I had never used them before. They seemed to work all right for a while. After the plant had been in use a short time, we received a hurry call, saying there was no water in the boiler, and we found that some person had been interfering with the blow-off valve at the bottom of the boiler, when the steam had gone down, and the vacuum had drawn the water up into the pipes. We gave them the necessary instructions to avoid this. But a short time after we received word from the same plant, saying there was no water in the boiler, and we found upon investigation that, apparently, our instructions had been followed in regard to the valves at the bottom of the boiler, and yet on two or three occasions the water left the boiler by being drawn up into the system. We did not have time to make any changes in the returns, which might have overcome the difficulty. A check valve placed in the return pipe might have been a help. But they wanted the heat, so we had to take the vacuum valves off and put on regular automatic air valves. I would like to hear from others, if they had similar experience with these valves, and what has been the remedy.

Mr. Bishop: Referring to the part of the paper that speaks of the efficiency of house-heating boilers, I believe Mr. Bryan's idea probably was applied to the usual conditions under which the boilers are supposed to operate. I have found, by examining boilers and making tests of consumption of coal for the full heating season, that the efficiency of house boilers is in many cases lower than that stated by Mr. Bryan. I think that is brought about largely from the fact that the man who tends to the firing of the boiler is not in constant attendance, and that he throws more coal on the fire-box than will properly burn to advantage, and in that way decreases really the working efficiency of the boiler; though the boiler itself is just as efficient, the result from it is not quite as good.

In regard to the question of the deterioration of the return line in a heating plant, the company that I am connected with has had considerable experience. At the present time, where houses are heated from the street mains, there is placed in the building heated about one-fifth of the radiation, in the form of indirect radiation, ahead of which is placed a steam trap, and only the water of condensation from the direct radiation enters the indirect radiation, which is known as "economizing coils." From about 1882 to about 1890 this economizing coil radiation was made up of wrought iron pipe, and in from five to nine years it was found that the wrought iron hot water coils gave out. There were many experiments made then as to the cause of the deterioration, which was found to be the result of the quality of the water, it being found that steel pipe was eaten up in the shortest time, and cast iron pipe was not affected; therefore this indirect hot water radiation is being installed by the use of cast iron radiation, and without the use of wrought iron nipples, each section of the radiators being flanged.

I saw last year a piece of 2½-inch pipe taken from a supply line that had been in the ground since 1887 and in actual use for eight or nine months of each year. Upon examination, it was found to be in perfect condition on the inside. The outside was also in perfect condition. The weight of the pipe was a little more than commercial weight of pipe of to-day, showing there had been no deterioration in any respect. Wherever the pipe had been lying in moist ground or surrounded by moist ground, and there was deterioration, it was from the outside.

One of the arguments just brought up about the giving out of pipe is the reference to the giving out of pipe in places. We have found that this is due to the carbon used in the manufacture of the pipe, which if it can be kept out of its manufacture, there would be no effect of deterioration, if the temperature is high enough; but if carbon is in the pipe it will pit in the places where the carbon is to be found. The greatest distribution of carbon known that is allowed in steel pipe, so far as I know, is 1-10th of 1 per cent. However, no manufacturer of steel pipe can evenly distribute the carbon, and so there are little points here and there where the carbon is bunched, and it is at these places that the pipe gives out. Cast iron pipe, I think, would be indestructible for the use referred to.

Our company has given a great deal of consideration to joints of cast iron pipe when used to carry steam or hot water. Of course you all know that lead is precluded because it does not expand again after contraction as does iron, and the joints which have been used have also proven of unequal expansion, which broke the bell. Our company has done some work and experiments with heavy cast iron couplings, using special joint pipes and cast iron couplings, and found no difficulty.

The "kal" is a measure of heat adopted, and, I believe, exclusively in use by the New York Steam Company—not in any way connected with the company that has been mentioned. The method of charging for steam delivered in the 176 district plants that I am familiar with is divided a little peculiarly. In the plants that do strictly a heating business, 80 per cent. of them charge upon a meter basis. There are two types of meter aside from the one meter that is used in New York City, which one measures in kals, and which has quite an arrangement of valves and clock attachment. It is difficult to get a customer, perhaps, to think that it is correct. The other two meters are velocity meters and meters that measure the amount of condensation, and the latter is really the true way to measure the amount of heat delivered to a building. You can apply the evaporating duty of the fuel in computation of the amount used as shown by the amount of condensation, represented by the reading of meter in pounds of water, and you have the amount of fuel that the man has used, and he can believe his meter, and you can make him believe it by simply

weighing the water discharged by the meter and having him mark the counter while the test is being made. The companies whose heating is by exhaust steam, a by-product, are mostly charging on a space basis or a radiation basis, on a contract system; these are the two ways of charging. The cost is determined largely by local conditions, and it varies from as low as six cents to as high as seventy-two cents per square foot of radiation per year. The space heating runs from as low as seventy-five cents a 1,000 cubic feet of space heating to $5.50. Those are unusual conditions. The amount of radiation in the paper here—he said that the charge was from twenty-five to fifty cents, I think, a year for steam radiation, and from about twelve and one-half to twenty on water radiation. If you did not carry in mind the facts, the statement might be a little misleading. Steam companies that do a district work have the houses piped on an average basis of one square foot of radiating surface to each 100 cubic feet of air space heated. The water jobs are piped, as any hot water fitter will say, from 25 to 30 to 1, and where the building has but one or two outside wall exposures and very little glass surface, it has been piped for steam as high as 150 to 1. So, in any case, you either double or treble the hot water charge per square foot of radiation to make it the same as the steam rate.

Mr. B. H. Carpenter: I should like to ask, in the case where they measure the water of condensation, whether they take the water of condensation from the street or a pipe leading to it, or how they get rid of it.

Mr. Bishop: The subject of district steam heating covers about a quarter of a century, and all the earlier plants constructed had the steam from the bottom of the line, consequently they had more or less street water in each building. To-day there is not a method of taking care of expansion and contraction or a method of insulation in use that was in use ten years ago, and hardly any that was in use five years ago, and the present process in taking steam is taking it from the top of the line. I was talking a few days ago to the editor of the "Minneapolis Tribune," who owns a plant at Grand Forks. He has just a mile of mains there, and he has the condensation meters placed on each house heated, and also on the low points of the street line, and he charges his customers with the amount

of condensation in their house alone, taking it, as I said, from the top of the line. Taking all the meters together, they register the same amount of water that his meters on the boilers did, except what he had used for washing boilers and such other little things as require the use of water about the station, and he said that his output of steam for the month of October was only 10 per cent. of the capacity of the line, while his radiation loss, as measured by the condensation meter of the street, was 2.95 per cent. of his output.

The Chairman: Is Mr. B. H. Carpenter able to give us some experience with central stations?

Mr. B. H. Carpenter: Mr. President and gentlemen, I have not had any very great experience in this line. We have experienced the giving out of pipe the same as all have, but I have not been able to get at the direct cause of it. Some little time ago we thought probably the pipes were affected by currents of electricity. The pipe seemed to give out more from the outside. The places in which the pipes were placed seemed to have a great deal to do with the difference in length of time which they would last, whether it was in a dry or a wet soil, whether it was in clay or ashes, but I have not made any tests on it.

Professor Carpenter: In regard to electrolysis, which Mr. Carpenter refers to, I think we should find, whether we used cast iron or wrought iron or steel, we should not escape the effect of electrolysis. It seems to eat through cast iron pipe as quickly as it does through steel. I was not referring to that particular source of trouble in my remarks. That is a source of trouble which I believe the electricians state they know less about to-day than they did five years ago.

Mr. Keyser: Referring to what Professor Carpenter and Professor Kinealy have said, I am reminded of something I came across some time ago. I took out a radiator in which the nipples were slit nipples, a cone driven together, and the nipple was perfect in every point excepting the bottom, where the condensation ran through, which was probably three-quarters of an inch or an inch wide. At that point it was scored through entirely, while the other was perfectly good, which points to the water, I believe.

Professor Kinealy: I asked the question of Profesor Car-

penter for two reasons. One was that I wanted to get information, and the other was that I wanted to bring out clearly the conditions that existed in the pipe. Last spring I was asked by one of my colleagues, the professor of chemistry, to give him some aid in a matter that is very much like the one we are discussing. He had been retained by a large company operating and building ferry-boats, to determine what was the best material with which to sheathe ferry-boats. They had been using a sheet steel, and it had been rusting and giving out. He made experiments, and he looked up all the literature of the experiments that he could find on the subject of the rusting out and deterioration of iron or steel in water. Now, experiments seem to indicate that distilled water acts very rapidly upon iron, and iron—pure wrought iron—appears to be less acted upon than an iron that has a small amount of carbon, or even than steel. But when you begin to go beyond what we ordinarily call steel—that material made of iron with a larger per cent. of carbon—and approach the condition of cast iron, the water does not appear to act so rapidly. In other words, the best material appeared to be the pure iron without any carbon, or the iron with enough carbon to make cast iron. But that did not hold good with all kinds of steel; a certain amount of manganese, for instance, I think improves the quality of the steel, so far as the deterioration due to water is concerned. It is quite a large problem, and this man is still working on it, making experiments of all sorts.

In regard to the efficiency of house-heating boilers, I want to say a word or two. If you will take the ordinary house-heating boiler or furnace, and calculate its efficiency from the water heated or the steam evaporated during a whole year, using as your basis the coal used during the year, you will get a very low rate of evaporation and a very low efficiency. That is very different, however, from the condition that you have when you make a test. A great deal of the coal which is burned in the ordinary small house-heating boiler or furnace is burned simply to keep up the fire in mild weather. You can cut your consumption down pretty nearly 50 per cent. by not putting coal on at night, and your boiler will keep fire until morning, and that I think is what Mr. Bryan included. There are some terms that are used here that are new to me; for instance, this

word " kal." I never heard it before, never saw it before that I know of. I should like very much, for my own information, to hear from the gentlemen present as to the cost of heating. Mr. Bryan gives some figures here as to the number of pounds of coal, for instance, required per season, or for 24 hours, per square foot of surface, hot water and steam.

It seems to me that we have discussed only one part of the paper. There is a great deal in the paper—so much that it is very difficult for us to discuss it all. There is a point that has not been discussed at all, and that is the storing up of this heat. I should like to know how large a plant one must have in order to store up a given amount of heat. There is a system, you know, that is being used, where they store up the exhaust steam in large hot water tanks, and I should like to hear about it.

Mr. James H. Davis: I do not think we can agree with Mr. Bryan on the point that it does not pay to bring the return water back to the boiler room. He speaks of a system wherein they use cooling coils to reduce the temperature of the return water to a point where there is little value left in it. I at one time was called upon to take temperatures on such a system, with a view of reporting whether it would pay the company to put in a series of return pipes, and I found that while the air outside was about 30 degrees, the temperature of the water from the cooling coils ranged all the way from 130 to 190 degrees. This range of temperature included the examination of some 15 or 20 buildings.

Now, we all know that unless there is a large surplus of exhaust steam at all times at the power-house, water coming back to the boiler room at a temperature ranging from 130 to 180 degrees would represent a saving of from 8 to 14 per cent., provided the new water was at a temperature of 50 degrees, which is about the temperature we would obtain from street mains during the winter season.

Moreover, the saving to be effected by not having to pay for new water should be considered, and I am of the opinion that it is safe to say that there is a saving to be effected by using return water ranging from 10 to 20 per cent.

I should also like to correct a statement that Mr. Bryan has made with regard to the charge at Seattle. The price there is

seven cents per square foot per month, and they heat about six months in the year.

Mr. Paul: In regard to the question of pitting and destruction of return mains, I want to say that we have had some experience. In one case at the time the system was changed from a pressure system of 40 pounds down to circulation of steam at the atmosphere, it was found that the pipes were so pitted that when any appreciable vacuum or minus pressure was put in the return pipes, they were shown to be full of holes. It was in the early stages of my experience, several years ago, and I should say that these same return pipes are there to-day. The engineer merely peaned up the holes. The pipes have not continued to deteriorate since the change in pressure of the steam. That seems to show to me that it was something besides the water that produced the deterioration of the pipes. Of course, I have to agree with the gentlemen who have spoken in favor of cast iron, that cast iron is much better than wrought iron. I do not intend for a minute to claim that wrought iron is better than cast iron for the purpose. But the experience that we have had, and especially in plants where we have taken old buildings, where steam had been circulated at all kinds of pressures and in all kinds of service, shows that when we circulate steam at low pressures, at the atmosphere or below, there is an entire change in the interior surface of both the mains and the radiators. So great is the change that we have often been obliged to clean out returns, and we have got bushels of coal and dirt that had come down from the heating surfaces. It is my opinion that in the circulation of steam the air is given off at the point of condensation, the water drops down, and leaves the air present. Now, we know that water in that condition will produce rust, especially if free air is allowed to enter the system. When the system is placed under a minus pressure, the tendency of the air that has been imprisoned by the scale is to be freed—blown off, as you might say—so that we have had 1¼-inch or 1½-inch pipes filled up solid with scale, where they had been perfectly free before the pressure in the system was reduced. And the same pipes have continued in use, and I do not know of a case in which we have been obliged in ten years to put in new pipes, although we have taken old plants that had been in fifteen years before we made the change. The

plant that I spoke of first was the first plant in Chicago put in after the great fire, and the same pipes and the same everything are in the plant to-day that were put in at that time.

In regard to the question of circulating steam in large plants and carrying it for a long distance for central station work, we have a plant that has been in use now for six years, in which the electric light company has circulated steam through something like, I think, 6,000 feet. The water of condensation is discharged at any point that is desired. No water is returned to the station. It was the Holley system that was put in originally, and the system was afterwards changed, but the water was not returned. With this system, in the winter time, they are able to circulate steam throughout the entire village, and really carry less back pressure on their engines than they do during the summer months. In the summer months the exhaust pipe is not sufficient to carry the exhaust to the atmosphere, and, therefore, there is a natural back pressure; but in the winter months the condensation of the steam in the different heating plants along the line takes away that natural back pressure. We also have plants running where live steam is made and circulated, where there is no exhaust, and where we are circulating up hill and down hill, and the station plant is something like 15 or 20 feet above our heating work. Live steam only is used, and the plant runs the year round, for the reason that it is located in a cold country, and consequently they have to heat during the summer months, so that they sell steam the year round. We cannot get many data from some people who are circulating hot water, and, therefore, we cannot compare what they do with what we are doing.

Professor Kinealy brought out one point which I shall try to explain. We have tested very carefully to determine the amount of steam used for 24 hours to maintain 70 degrees temperature inside with practically zero weather outside. We have found that a quarter of a pound of coal per square foot of surface will take care of a building for 24 hours, and we have also found that the amount of coal required is governed, to a certain extent, by the amount of surface in the building. If you put too small an amount of surface in a building you will run up the amount of coal used per square foot of surface considerably. But having sufficient surface in the building,

and having it properly taken care of, so that it will not use any more steam than is necessary, you can work on about a quarter of a pound of coal per square foot of surface per twenty-four hours. To my mind, there is no question but that the district heating is going to be carried on to a very much larger extent in the future than it has been in the past. To-day there are many people who are prepared to put in district heating. I have a very large list of plants of that kind. There are also many plants that have been put in under the Holley system, and under other systems, where pressure is used that the owners are desirous of remodeling. They have found that there is economy in reducing the pressure. Only to-day a gentleman came to me and said: "We have been using 15 pounds pressure; we have 176 buildings that we heat, and we cannot get satisfactory work; we get water throughout the different plants, and we are called upon to make many changes, and send men from plant to plant in order to get over the trouble." All these troubles seem to disappear in any heating plant when you make one uniform pressure throughout the entire system. If you have a plant working under a uniform pressure throughout the entire system, your trouble with water disappears. It is the change of pressure that gives you trouble with water. If you can put a pressure on to the supply pipe and have that same pressure on the farthest radiators, you will have no more trouble with water than you will in pouring water out of a glass in this room, where there is a pressure of 14.7 pounds at every part.

Mr. Bryan:* I am gratified to note that my somewhat hastily prepared discussion of this subject has proved of so much interest. Little further need be said, however, as many of the points brought out in the discussion have been answered by other speakers.

My statement as to the low efficiency of the average house-heating boiler was based upon the manner in which it is usually run. In mild weather a very light fire is carried, while in severe weather it is usually forced. It is charged with fuel as infrequently as possible, and has no careful or skilled attention whatever. It has been shown repeatedly that such conditions result in very low efficiency for any kind of boiler, and the heating

* Author's closure, under the Rules.

boiler is no exception. If it could be intelligently fired, and operated at or near its rated capacity, it would probably do reasonably well. In fact, the low temperature at which it is permissible for the chimney gases to escape should improve the efficiency. Admitting this, I am still of the opinion that my figures for average efficiency are not far in error.

As to Mr. Davis's statement that returns should be brought back to the station, I can only reply that experience has shown otherwise. I can readily imagine, of course, that where all the customers are reasonably close to the station, where the grades are favorable, where fuel is expensive, and where cast iron mains are employed, there might be exceptions to this rule.

Mr. Paul must certainly be in error in his statement that one-quarter pound of coal per square foot of radiating surface per 24 hours will keep a building at 70 degrees, with an external temperature of zero. Under these conditions, if the heating surface is properly proportioned to the building, and there is a stiff wind blowing, each square foot of radiating surface should condense about one-quarter of a pound of steam per hour, or 6 pounds in 24 hours, which would require the burning of about one pound of common coal. Of course, if there was a great surplus of radiation in proportion to the work to be done, or if there was no wind, a considerably less amount of fuel would be sufficient.

LXXXIII.

PROPORTIONING HOT-WATER RADIATION IN COMBINATION SYSTEMS OF HOT-AIR AND HOT-WATER HEATING.

BY R. C. CARPENTER.

(Member of the Society.)

In the construction of heating systems where hot-water radiation is combined with air warmed by a furnace, much difficulty has been experienced in securing the proper proportions of the two systems. In many of the plants which have been erected much trouble has been experienced, due to the fact that the heat which is generated by the coal is not distributed as required to the various portions of the building, and that either the hot-air portion or the hot-water portion took an undue part of the total heat.

Judging from my own experience, which has not been extensive in this line of work, the hot-water radiation is usually insufficient in amount to radiate all the heat taken up by the hot-water fixture in the furnace, the result being that when the furnace is crowded, the hot water in the radiators may boil and give off steam, and in so doing create a considerable amount of disturbance. In the combination systems of hot-water and furnace heating it appears to be customary to use a hot-air furnace of the ordinary construction, which is modified by inserting a cast-iron vessel or a coil of iron pipe in which the water of the system is warmed. A system in ordinary use is a hot-air furnace with a hot-water supplement, and belongs rather more closely to the realm of furnace heating than to hot-water heating.

I have found it a matter of great difficulty to secure any accurate data on the relative amount of water-heating to fire-heating surface which should be placed in a hot-air furnace in order to give satisfactory results. I have also found, from sorry experience, that the data furnished by the furnace makers for

proportioning the radiation which will be carried by a hot-water attachment placed in the furnace are altogether unreliable, and in many cases positively misleading. I presume many of the members of the Society can give many reliable data on this subject, and, if so, I am in hopes that much information will be gathered as the result of the small amount which I volunteer. I shall present in a brief form results of some experiments in proportioning heating surface in a hot-air furnace to hot-water radiation and an accurate test of the efficiency of the different parts of a furnace and combined with a hot-water heater.

My first experience in supplementing the power of a hot-air furnace by the addition of a certain amount of hot-water radiation was many years ago; the furnace specially used at that time being one adapted for long sticks of wood fuel. In this particular case it was required to warm up a certain portion of the building which was not heated by the hot air, and the problem was simply the balancing of the heating surface in the furnace with that of the radiating surface in the building. It was decided to insert a circulating coil of wrought-iron pipe into the furnace to supply the necessary heating surface, which was made of 1½-inch pipe, extending completely around the furnace, directly above the fire box. The amount of radiation installed was 150 square feet. Every authority at hand was consulted in order to determine the amount of heating surface before constructing the furnace coil. The best authorities seemed to indicate that for each square foot of radiation there should be supplied one-third of a square foot of heating surface, and in constructing the coil it was made on this proportion. The results of this experiment, while it seems rather funny at the present time, were at the moment rather serious. After completing the work, fire was started in the furnace, the workmen left, and everything was apparently in the finest condition; in fact, such was the case when I went to bed. In the middle of the night I was awakened and requested to come immediately to the house in question, because the furnace was groaning and there was such an internal pounding and such an infernal noise that it was believed the apparatus would explode. The only remedy which I could suggest was to let the fire go down and to keep it low until some of the heating surface could be re-

moved from the furnace. The authorities consulted had evidently been very much in error, or, at least, their advice was not applicable to a wood furnace. The heating surface was reduced little at a time, until it was finally brought to the proper proportion, in which case it was only 10 per cent. of that first installed. The final ratio which proved satisfactory in a wood furnace was one square foot of heating surface in the furnace to 30 square feet in the radiator.

A later experience with the application of a hot-water heating system to a hot-air furnace also required a number of trials

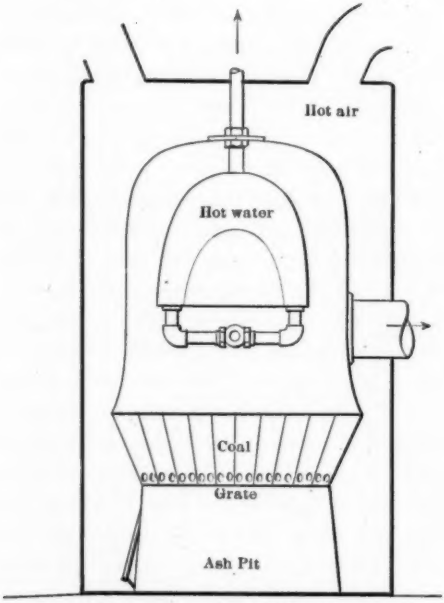


FIG. 1.—SECTION OF FURNACE.

before the combined system was a success. In this case the furnace was a coal-burning furnace, with grate 20 inches in diameter, which had been installed for some years. The furnace failing to heat all parts of the house, it was decided to install a sufficient amount of hot-water radiation to make up the deficiency. To obtain the heat for warming the water in the radiators, a cast-iron vessel was located in the upper part of the furnace and directly above the grate. The cast-iron vessel

especially made was supplied by the maker of the hot-air furnace, and was provided with a very deep conical bottom, and located as shown in the sketch, Fig. 1, its bottom being about 20 inches above the grate. The return water was arranged to enter into the bottom of the vessel by two branches, the flow to pass from the top through a 2-inch pipe. The total heating surface in the cast-iron vessel, as measured, was 6.6 sq. ft., in the connecting piping inside the furnace was 2 sq. ft., making a total of 8.6 sq. ft., of which about one-half was exposed to the direct radiant heat of the furnace fire and the other portion well situated for receiving heat. The hot-air furnace contained approximately 65 sq. ft. of surface for heating air and 2.2 sq. ft. of grate. Learning wisdom from my previous experience in this kind of work, I decided to put on a sufficient amount of radiation to absorb all the heat taken up by the heating surface in the furnace. With this end in view, I attached 255 sq. ft. of radiation in the form of cast-iron radiators and 30 sq. ft. in the shape of uncovered connecting pipes, making a total of 285 sq. ft.; this amount was fully double that advised by the maker of the hot-water heating appliance. The results of the first trial were unsatisfactory for an entirely different reason from that previously mentioned; namely, that the radiators did not get sufficient heat to keep them at a temperature sufficiently high to warm the rooms. An investigation showed that the chimney from the furnace was extremely hot when a good fire was maintained, and that consequently a large próportion of the heat which should have been used in warming the building was passing up the chimney. The system was in effect a failure, as it did not warm the building; nor was it economical. I then decided to locate a radiator on the return pipe near the furnace and construct my smoke flue around this radiator in such a manner as to absorb as much of the chimney heat as possible. A thin cast-iron radiator containing 15 sq. ft. of heating surface was supported in a horizontal position and a smoke box of the horizontal dimensions of the radiator and 5 inches deep was connected to one end of the furnace and at the other end to the chimney; some baffle plates were put in to drive the heated gases over the radiator. This was a success so far as reducing the heat discharged by the chimney was concerned; its results at the end of the year showed a saving in fuel of fully one-third

as compared with the previous two years. A practical trial, however, showed many defects in my economizer. The smoke flue was too cramped, and at the end of the second year the radiator had become so badly encrusted with soot that the smoke passage to the chimney was nearly choked. The effect was also seen in the diminished heating power of the system. I then reconstructed the economizer, taking pains to correct any faults which had appeared from two years of use. In its reconstructed form, I used a flat radiator containing 22½ sq. ft. of surface, and constructed around this a galvanized iron casing 4 ft. by 2 ft. 3 in. in horizontal dimensions and 9 in. deep. I also provided ample doors for cleaning the economizer. In this construction I made no effort to drive the heated gases over or through the radiator, but simply suspended the radiator in

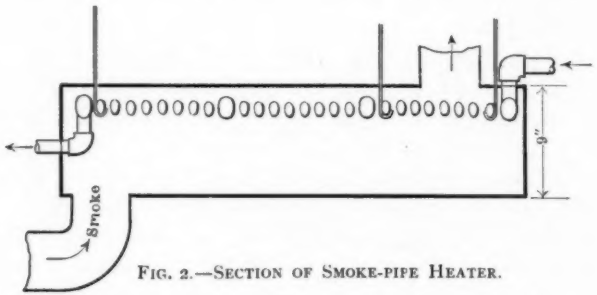


FIG. 2.—SECTION OF SMOKE-PIPE HEATER.

the upper part of the casing, where it would naturally receive the highest heat of these gases. The results with this arrangement have been highly satisfactory, and the relative proportions of hot-water-heating surface and hot-air-heating surface seem now to be as nearly correct as possible. The return from all but 100 sq. ft. of the radiating surface passes through the economizer, and in so doing is usually warmed about 7 degrees, although in some instances as high as 15. The ratio of hot-water-heating surface to hot-water radiation is as 1 to 33, which is not essentially different from that found to be necessary in the case of the wood furnace. In computing this ratio, the indirect heating surface in the smoke flue is not taken into account. If this be taken into account, the ratio is as 1 to 9.2, which approximates that of the ordinary hot-water heater.

The rise in temperature of water caused by the principal

heating surface is about as follows when outside temperature is 22 degrees: inside temperature, 70 degrees; temperature of water in flow pipe near furnace, 145 degrees; temperature of return water entering main heater from economizer, 116 degrees; temperature of water entering economizer heater, 109 degrees; from water in radiator, 140 degrees; water in main return, 109 degrees; temperature exhaust gases, 225 degrees.

The following shows in tabular form the dimensions of the various rooms and the method of heating, with dimensions of radiators.

Although there is a downward current, with about 1 ft. 6 in. head from the economizer to the lowest point of heater, there has been no difficulty with the circulation.

First Story. 9 Ft. High Rooms.	Dimensions. Ft.	No.	Windows Area. Sq. Ft.	Exposed Wall. Sq. Ft.	Cubic Feet.	Radiation. Sq. Ft.
Parlor	14 x 15	2	74	261	1,890	Hot air
Dining-room	15½ x 11½	4	80	126	1,880	Hot air
Sitting-room	14½ x 16	2	56	144	2,100	Hot air
Hall	16 x 7	1	112	162	1,108	Air and 37.5
Bedroom	9 x 12	1	20	108	972	21
Kitchen	12 x 15	2	40	108	1,615	No heat
Second Story. 8 Ft. High.						
Study	15 x 14	3	54	232	1,680	Air + 50
Bedroom	14 x 14	2	80	112	1,572	Hot air
Bathroom	10 x 7	1	20	126	560	Hot air
Alcove	8 x 10	1	30	144	640	No heat
Hall	20 x 30	1	20	72	672	No heat
Bedroom	13 x 10	3	60	80	1,040	Hot air
Bedroom	7 x 10	1	20	64	560	22.5
Back hall	6 x 14	1	20	160	672	22.5
Third Story.						
Bedroom	29 x 10	2	16	250	2,030	100
Total					18,004	

During the past year I had an opportunity of testing a combination hot-air and hot-water heater under conditions which permitted an exact measurement of the heat given off by each system of heating. In this heater the hot air was all discharged through a single pipe 9¼ in. diameter. The grate was circular, 21 in. diameter. The heating surface for hot water consisted of 21 ft. of 1½-in. pipe coiled spirally around the fire box, thus giving 10.29 sq. ft. of heating surface; the ratio of heating to grate surface was 4.29, the area of discharge for hot air was 0.466 sq. ft. In order to measure the capacity of the heater, two tanks were arranged vertically over the heater at a height of about 20 ft.; one of these tanks was connected with the flow

pipe from the heater, the other with the return. Water was withdrawn in small amounts at regular intervals from the tank connected with the flow, and a corresponding amount reduced in temperature as desired was added to the return tank; by this method the exact amount of heat absorbed could be accurately measured and an artificial circulation was produced. The level of the water in the tanks was kept essentially constant during the test. The temperature of the water in the discharge and return was read by thermometers inserted near the heater.

The air issuing from the discharge flue was computed by measuring the velocity and temperature, computing the volume, and multiplying this by the weight of a cubic foot of air under similar conditions.

The coal burned during the test was also measured. Two tests were made, the results of which are recorded in the tabular form directly following these remarks. In the first test the rate of circulation was somewhat less than in the second, and the heat units absorbed per minute show a corresponding reduction. In the first test coal was burned at the rate of 2.76 lbs. per sq. ft. of grate surface per hour, and of this heat about 70.7 per cent. was absorbed in heating the air and water; the air taking up nearly 50 per cent. more than the water. In the second test 6.11 lbs. of coal were burned per sq. ft. of grate per hour, the total efficiency being somewhat less than 40 per cent. In this test the heat absorbed by the water was about one-sixth greater than that absorbed by the air.

Considering the amount of heat as given off by 1 sq. ft. of hot-water radiating surface as 200 B. T. U. per hour, which is approximately correct under conditions of coldest weather, we compute the amount of radiating surface which will be supplied under usual conditions by each test by dividing the total heat absorbed by the water by 200.

From these tests, made under different conditions, it would seem that the combination system of hot-water heating in connection with a surface does not preserve a uniform ratio of performance in the operation of the various portions. The hot-air system takes up the greater portion of the heat for a smaller consumption of coal than for a larger, from which it would seem that the portions of a building warmed by the hot air would receive more than the proper proportion of heat during com-

paratively mild weather, and less than the proper proportion during the coldest weather and at times when the hardest firing must be practised. This would also indicate that it is difficult to keep two systems such as hot water and hot air balanced for all conditions of firing. The reason for this is probably due to the fact that the absorptive capacity for heat of the two substances—water and air—obey different laws, and that the conditions which render the one most active are not so favorable for the other.

	JUNE 1ST.	JUNE 2D.
Mean delivery of water, pounds, per minute		14.00
Mean difference in temperature between inflowing and outflowing water, degrees Fahr.	10.75 42.69	53.0
Time of run in minutes	244	180
Net coal burned during this time	27	44.0
B. T. U. supplied per minute	1571	3470
Coal burned per sq. ft. grate surface per hour	2.76	6.11
B. T. U. absorbed by the water-heating system, per minute (10.75 x 42.69)	459	742
B. T. U. absorbed per minute, per sq. ft., water heating surface	44.60	75.2
AIR.		
Average velocity of air through heating Fahr., per minute	463	534
Average difference of inflowing and outflowing air	250.44	272.0
Cu. ft. of free air per minute	215.8	247.5
Weight of cu. ft. of air at this temperature and pressure	.050	.0402
B. T. U. absorbed per minute by this air	653	644
Pounds of air per minute	10.79	9.94
Total B. T. U. absorbed by air and water systems per minute (a)	1112.00	1386.0
Total B. T. U. supplied per minute (b)	1571.0	3470.0
Total efficiency of furnace (ab)	70.7	39.9
Total sq. ft. of radiation for 200 B. T. U. per sq. ft.	187.7	222.6

DISCUSSION.

Mr. Blackmore: The paper is a very interesting one, because it verifies the experience of almost every engineer that I have talked with on the subject, that a combination system is very difficult indeed to plan. I know it has been so in my experience. I have tried numerous methods of planning such systems, but, as Professor Carpenter says, when I got the plan of coil arranged for a given rate per square foot of grate per hour, I was entirely at sea when they increased the combustion of the fuel to double the quantity arranged for, so that I gave up the problem, and for five years I have never advocated or had anything to do with the combination system of hot water and hot air. I have heard of some who have found some satisfaction in them, but a great many more have had experience similar to my own. The paper is interesting, because it bears out the experience of these engineers, and it shows why this trouble is experienced.

Mr. Kent: I am specially pleased with the paper, because Professor Carpenter so frankly admits the joke upon himself about estimating the amount of heating surface in the coils. It seems he put the coil right in where the full flame can get at it, and this accounted for its being of so much value, while in boilers nine-tenths of the heating surface is removed from the fire, and only subjected to gases of decreasing temperature.

Secretary Mackay: In regard to the heat economizer that Professor Carpenter has attached there, my experiments show that it would tend to retard the circulation on that line of pipe. I found that when an expansion tank was connected to a return line and the water was expanding, the circulation stopped and the line would stand in check. It would seem to me that a better application would be to make it auxiliary to the boiler by connecting it back into the flow main, and allow the return main to come back the regular way. It would seem that raising the return water of a hot-water system the number of degrees which he mentions there—seven degrees—would necessarily retard the flow of the circulation, while he did utilize the waste heat, and the other way would seem to me to utilize the waste heat and not retard the circulation.

Professor Kinealy: This is a very valuable paper, and will be a great addition to our Transactions, because it deals with the facts. I want to ask a question, and that is whether or not I understood Professor Carpenter to say that when he increased the circulation of the water in the heater he got more heat from the fire to the water?

Professor Carpenter: Yes, that would practically be so. That is, when with the firing hard, and the water circulating more rapidly, the water took up relatively more heat than the air, and under the reverse conditions the air took up more.

Professor Kinealy: Did the circulation increase the amount of heat transferred from the hot gases to the water?

Professor Carpenter: Let me give you the figures. The heat units absorbed by the water-heating system per minute, when with a small circulation and with a low fire, was 459. With the greater rate of fire it was 742.

Professor Kinealy: The same surface?

Professor Carpenter: The same surface exactly; but the air absorbs 463 for the low rate of firing, and 534, very much the

same, where the water absorption was increased greatly. That is, the amount of heat absorbed by the air portion of the combination did not change greatly in changing the rate of firing.

Professor Kinealy: In changing the rate of firing you got a hotter fire, I suppose. What I am getting at is this: It has been claimed, and we have had a paper before this Society on the subject, that the smaller the capacity of the hot-water heater, and therefore the more rapid the circulation, the better did the heater work. So, in this case, the smaller the capacity of the hot-water radiator, the better did the radiator work. I am trying to see if that is what is brought out here.

Professor Kinealy: In other words, then, in a hot-water heater we want a small amount of water, and in a hot-water radiator we want a small amount of water, and we want that amount of water to be circulated rapidly throughout the whole system—the radiator and heater. That is what I was getting at.

Professor Carpenter: I think that is true. In fact, we have some experiments on this line, that as the rate of circulation of water over a fire surface increases, the efficiency increases. In order to prove this point I had made some cast-iron sections, I think 2 ft. long, 1 ft. wide, and 2½ in. deep. I made a fire box of them, using eight different sections. We measured the heat taken up by each of those sections, set around the fire in the form of a boiler. We found that as we increased the circulation through those sections the efficiency was increased.

Mr. Kent: When you increased the circulation you got lower temperatures of the water inside, didn't you?

Professor Carpenter: I would not be able to give the temperature now without looking it up.

Mr. Kent: It was not boiling water?

Professor Carpenter: No, we kept it below the temperature of boiling so that we could measure the temperature.

Mr. Bishop: I would like to ask if you increase the velocity of the water without increasing your temperature, would you increase the efficiency of your radiator surface?

Professor Carpenter: I think probably you would; but I don't know that I have any facts bearing on the subject.

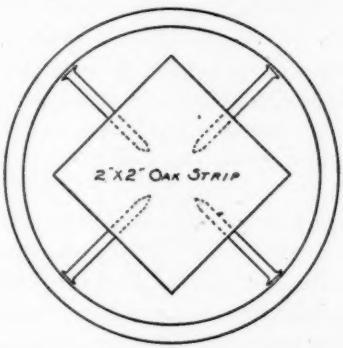
Professor Kinealy: I was not present when the paper in which the volume of water circulating in a hot-water-heating system was discussed was read before the Society. I read it

afterwards at home, and then I looked up what I could find on the subject, and I came to the conclusion that the more rapid the circulation of the water the better would the system work. Not only would the heater be more efficient, but the radiator would be more efficient. As to rapidity of circulation, what I mean is this: It is better to have the water enter the radiator at, say, 170 degrees and leave it at 150, so as to have an average temperature of 160, than it is to have it enter at 180 and leave at 140, having the same average temperature of 160. You will get the rapid circulation when you have a small capacity in your radiator per square foot of heating surface, and small capacity in your boiler per square foot of heating surface. Of course, if you make your capacity too small you increase your friction, and thereby may retard your circulation. I would like very much to hear from some of the gentlemen connected with the manufacture of hot-water boilers on this subject.

Secretary Mackay: Mr. President, hot water has been very largely used for heating green-houses, and the original practice was to make the boiler of the same material as the radiating surface; that is, if they use 4-inch cast-iron pipe to place around the green-house, they used 4-inch cast-iron pipe to make their boiler out of, and they usually put it in brick work. It was all made of the same material. Such apparatus was very largely used in New York City and vicinity; hundreds have been used here. The body of water was so much in proportion to the grate area, and in proportion to the surfaces exposed to the fire. The circulation was sluggish and the results were usually poor. The same construction of apparatus has been made with 1½ to 2 inch extra heavy pipe surface; this reduced the body of water about 75 per cent., and better results and greater economy has been experienced. I think that the paper that Professor Kinealy refers to—I don't remember who submitted the paper, but it was discussed by some of our members, including Mr. Fish, of Boston, and he contended that a boiler made for steam and used for hot water did not give as good results as a boiler that had the space usually filled with steam cut out and the body of water reduced. He claimed that the boiler was overloaded with water, and that it interfered with the circulation. The same thing has been found in connection with radiating surfaces. I have found that with a 4-inch cast-

iron pipe having a 2-inch square strip inserted in the centre of it so as to reduce the body of water, better results were obtained from that same surface with the body of water reduced probably one-half, and in the construction of radiators it has been found, after considerable experiment, that a certain volume of water, in proportion to the square feet of surface, gives the better results; that a smaller amount would give too much friction; that a larger amount would be overloaded. In the construction of the modern types of hot-water boilers to-day, the object is to apply a large amount of surface to the fire in proportion to the amount of water that it contains, and to get results of economy by lengthening out the fire travel.

Mr. Cary: In considering a hot-water system of heating, the



matter of quantity of available heat stored in the water should be an important consideration, and I would like to ask Professor Kinealy, if in a case where a sufficient amount of water was not held in the boiler, in the system of piping, and in the radiators, to store sufficient heat, if he would introduce in such an installation a storage tank to increase the heat-storing capacity of the plant. To illustrate better what I mean, let us imagine a hot-water heating installation in operation in very cold weather. At night we bank our fire, and the result is a very slow combustion until morning, when the fire is cleaned and started at a much higher rate of combustion, thereby furnishing sufficient heat to keep the house at a comfortable temperature.

Now, under these conditions, if there is not an ample quantity of water in the system in which to store our heat at night, the house will grow cold before morning, and this trouble might

be remedied by increasing the quantity of water held in our system by adding to it a storage tank.

Experiments were made in England by R. Armstrong some thirty or forty years ago, and are reported by him in his little work on "Steam Boilers," with a view of determining the relative economy of boilers carrying a large quantity of water and those carrying less water, the evaporative capacity of both being the same.

He used in his experiments the old-fashioned wagon-top boiler, which had no flues or tubes in it. He first ran the boiler filled entirely with water up to the water-line, as it was originally intended to operate it. Then he placed supports from one side to the other of the boiler, a short distance above the lower shell, and filled perhaps one-third of the water space with bricks, and the balance of this space with water. He claims to have succeeded in getting better fuel economy with the decreased water space, and he further cites instances where other steam users subsequently obtained material saving with a diminished amount of water space in their boilers of similar construction.

Professor Kinealy: I was discussing the point from the view of efficiency of radiator and efficiency of heater; I was not thinking of storing up heat or anything of that sort. Of course, there is this point to be said in favor of the rapidity of circulation—the more rapid the circulation the quicker will the water heat. In other words, you would then approach that flexibility of heating and cooling that you have with the steam apparatus, and at the same time have the ability to circulate water and get low temperatures in your radiators in mild weather.

Mr. Cary: Very small amounts of water used in the system and very steady fire would be necessary in the furnace. Otherwise the fluctuation would be very rapid and great, and it could get to a point where it would be undesirable.

Professor Kinealy: Undoubtedly you can squeeze almost anything down until you get beyond the limit. What that would be I don't know.

Mr. Snyder: Mr. Chairman and gentlemen, I desire to bring forward a point more perhaps in the line of inquiry than anything else.

In the installation of heating and ventilating systems in the public schools of this city of New York we frequently have a building containing 48 class-rooms, say 48 units, which divided equally among four blowers would give 12 units hooked on to each blower. These 12 units, however, are probably located on three different floors, and as frequently there are three departments in a building, the control of each floor naturally is vested in three different persons, who arrange their recess periods at different times so as to avoid overcrowding in the yards.

The result is that as long as the rooms are all occupied and the windows and doors closed the plenum is maintained; but as the recess hour is reached for one of the departments the class-room doors are opened and hooked back, which immediately destroys the plenum of the other eight rooms dependent upon the same fan. We have tried almost everything; we now have springs on the doors, and have removed the hooks; but it is quite useless, as other means are found to secure the doors in an open position.

I have made several inquiries as to whether or not objections of this kind had been made, and if so, as to the remedy in the form of an automatic cut-off of the air in the flues of rooms the doors of which are opened.

I simply cite the case of twelve units, four of which are on a floor, all dependent upon the same fan, as an example; but whether it was one room out of eight or one out of twelve, of which the door was opened for any period of time, the result must be to disturb the plenum of the other rooms.

A year or so ago I met a very prominent inventor of Boston, and spent some little time explaining the matter to him, and he thought it easy of solution; but a few months ago he said he had not hit it yet. I have been wondering if any gentleman here could give us any information, as with us it is a very serious problem.

Mr. Cary: I have had no time to give any study to this matter presented by Mr. Snyder, but seeing no particular difficulty in finding solutions for the trouble named, with the understanding I have of the system described, I would offer a few suggestions.

Let us suppose, to illustrate what I intend to say, that the

air-supply ducts are run along the ceilings of the hall in a similar manner to the office building equipment which was described at the first session of this meeting, and let us further suppose that air from the supply duct is introduced to the rooms through openings located over the hall doors. Would it not be a comparatively simple matter to run a vertical rod through the centre of these door hinges (which would turn positively as the doors were opened or shut), and by attaching either gearing, or a system of simple levers to the top of this rod, have it open or shut a damper located just inside of the register through which the fresh-air supply is admitted to the room. I believe a very simple arrangement of this kind could be devised to take care of the door-opening troubles.

Mr. Snyder: The flues are, as a rule, owing to the necessities of construction, placed between two rooms. The doors might or might not be in the immediate vicinity. But, if the suggestion of Mr. Cary was adopted, would not that increase the supply of air in the balance of the rooms by just the amount that was cut off from that particular room by this automatic damper, and would not that create a draught, which, of course, we would desire to avoid?

Mr. Cary: This is a case of inventing on the spur of the moment. (Laughter.) Supposing we overcome the objection just named by not entirely closing these dampers, or else by making small openings in the damper so as to allow a sufficient amount of air to pass through to relieve the accumulation pressure, and thus we would not affect our air supply to the other rooms.

Mr. Kent: I recognize that this is a very important question. It was brought to my attention some years ago by the principal of one of the schools in New York City, who criticised the system of ventilation which was used there. This principal—it was a lady principal—said it was forbidden to open a door or a window; that the whole ventilation of that school had to depend on those regulations, that no door or window was to be opened; that she always despised those regulations, and always would. I said, "No system of ventilation can be good unless doors and windows can be opened. If opening them interferes with the plenum of the other rooms, there must be some remedy." The heating and ventilating engineers must not put themselves

above doctors and everybody else, and say, "You must not open the doors and windows." Mr. Cary has suggested a remedy, which I think can be worked out. When a door is opened there should be an arrangement which would partially shut a damper admitting the air into the room. Something can be done by which, when the windows and doors are opened to let the wind blow through, it will not interfere with the rest of the school.

Mr. Snyder: I brought the matter forward because nothing has ever been offered me to remedy this difficulty, and wherever I have investigated the heating and ventilating appliances of buildings I have found the same difficulty to arise, and it seems to me that there must be some inventive genius who could contrive some economical scheme that would cost very little for maintenance, and which would accomplish this desired result. I think there is a mint of money in it for somebody.

Mr. Barron: I would like to make an amendment to Mr. Kent's suggestion—that the make and break of an electric circuit would probably be found more desirable.

Mr. Kent: No doubt it would.

Mr. Joslin: You are taking twelve units and shutting four. Those four units have got to go somewhere.

Mr. Kent: I understand the Blackman exhaust fan establishes a certain pressure, and it will not establish any greater pressure for a certain velocity, and that your plenum will not be increased by shutting off a certain outlet. There is a certain pressure given by the fan and that is pressure that ought to be maintained thoughout the riser, and by taking out some of the outlets you will not decrease it very much. That is met, of course, by the partial closing Mr. Cary suggested.

Professor Carpenter: In the case of the Blackman or any other fan, supposing that we have very different velocities in our main flue and in the risers, and that this velocity is very much less than that due to the pressure of the fan, then what happens?

Mr. Kent: You mean the velocity would increase when you shut off some of the outlets?

Professor Carpenter: Increase in the remaining ones, because these are always at a lower pressure than the fan pressure. The velocity would increase, wouldn't it, in the remaining ones?

Mr. Kent: Possibly. If that is the case, we should have to allow some outlets into the room in which the windows were opened.

Mr. Cary: To continue my reckless inventive course, I will refer to an experience I once had, which led me to develop a remedy which will apply to this case.

At one time I had to deal with boilers using gas for a fuel, in the natural gas region.

Certain employees of the concerns using these boilers had an unfortunate way of first turning on the gas supply and then going in search of a torch to light the fire. During this interval the gas and air would mix in proper proportions to form an explosive mixture, and when the torch was applied something was apt to happen. In most cases the boiler would stand in place, but the walls would not stand, and the man who applied the torch would very seldom be found standing.

In order to relieve the excessive pressure (resulting from such explosions) as quickly as possible, I placed large doors of peculiar construction in the upper part of the setting. These doors were hinged at their top, and opened from the bottom, forming a sort of flap.

The seats or jams against which these doors closed (forming a part of the door-frame casting), instead of being (when in place) vertical, were placed at an angle, so that the closed door had a tendency to swing still further, in closing, to come to a a position of rest (had it not been restrained by the seat it closed against).

With the face of the door and its seat ground to a perfect fit, and the weight of the door tending to crowd it closer against its seat, a practically tight joint was formed which did not interfere with the draught condition, but when an explosion occurred, these side doors would fly open and often relieve the internal pressure sufficiently to save the brick setting of the boiler, and also sometimes save the man in front of the boiler, by not blowing out through the front doors to so great an extent.

Now, I do not see why such side doors could not be placed along the air ducts, and so balanced as to open with an excess of pressure above that which should be maintained for a perfect-working system. With such a "safety-valve" arrange-

ment the pressure of air entering the rooms could never exceed a certain predetermined limit.

Mr. Barron: I should like to ask Professor Carpenter if he does not think that if all the openings in a plenum system were suddenly closed, the only result would be that the fans would move around at the same speed, but there would be the loss from that load that is wasted. There would not be any change in the system or inconvenience, except the purely economic waste in running the fan.

Professor Carpenter: I think in that case, taking the ordinary systems as they are constructed, if we should shut all the dampers, we should find that the pressure would increase from the fan to the damper, until we had the same pressure at the damper as at the fan. The work done by the fan would diminish. It would run very much easier than when the air was passing through. But we would have a very much larger pressure next the register. Now, of course, if only one of the registers be opened, the air would flow through that register, with a velocity due to the pressure. That is, it would go through at a higher rate than ordinarily, but the fan itself would move more easily. It seems to me that Mr. Cary's last suggestion is the one that would have to be carried out. That is, if one room is shut off, it would not do to entirely close that register into it; simply close it down to such a point that the resistance would be the same as it was before the doors were opened.

Professor Kinealy: This kind of a problem comes up quite often, and if the units are arranged as Mr. Snyder says, so that you have only four units, the solution is very easy, as you can change the speed of your fan. This is especially so if your fan is run by a motor. I was speaking to a gentleman to-day who was telling me of a fan that had twelve variations of speed.

Mr. Snyder: There are twelve to sixteen units.

Professor Kinealy: Then, of course, that complicates it. But if the fan is run by an electric motor, you can change the speed easily.

Mr. Snyder: Most of them are run by a steam engine, and there are from twelve to sixteen units hung on a fan.

The Chairman: Is there anything further to be said along this line?

Mr. Barron: I should like to ask Mr. Snyder if he will kindly

tell us if he got any advantage from the discussion of this topic. If he is any farther ahead?

Mr. Snyder: Well, Mr. Chairman and gentlemen, I have not thoroughly digested everything that has been said, but it has set in motion a train of thought which may lead to some solution. The introduction of an auxiliary damper, which has been suggested by Mr. Cary, is rather difficult to carry out. The construction of our buildings is peculiar to this city. They are of entirely fireproof construction. The value of the land is very great, costing, for the eight or nine lots required, sometimes as high as $250,000. The Board of Education requires of its architect that he shall deliver to it as many sittings for that plot of ground as may be possible, and perhaps some of you gentlemen know quite well the difficulty there has been in gradually introducing forced or mechanical ventilation in the public schools of this city. We have followed it step by step, and when three years ago the proposition was made to erect a certain building upon a certain given plot of ground, immediately somebody stepped forward and said, " On such and such a plot of ground, in such and such a year, there was erected a building of a certain number of rooms of the same size—why the difference? "

It then developed that the amount of space taken by the heating and ventilating ducts was responsible for the loss of about one class room on each floor. Taking the example of the by no means unusual case of a plot of eight lots costing $250,000, we should then have the sum of say $7,500 paid for land alone to furnish the extra space for heat and vent flue area. Naturally the question of expense, therefore, enters very largely into all that we do; and in the adoption of all of these things we must meet this matter of construction, and the suggestion which has been made may possibly be worked out, provided we have some place to carry this damper to. All acknowledge that it will not be wise to lower the outlet. We hope some solution may be had, because I don't think that I am the only fellow that is in a hole.

Mr. Joslin: Would not a solution of the problem be to put the corridors of the entire building under pressure?

Mr. Snyder: Not in a building covering 16,000 square feet and five stories high.

LXXXIV.

TOPICAL DISCUSSIONS.

TOPIC NO. 1.

"Methods of Ventilating Office Buildings."

Mr. Jellett: Mr. President, if there is nobody else to start this question, I will do so, because I think it is one that we want to thresh out pretty well. The general subject of ventilation of office buildings has not been given very much consideration until within the last two or three years. There has been more done in this direction during the past year than any of the years preceding it. The enormous development of office buildings and the increased interest in ventilation and providing good air has gone beyond public assembly halls, schools, and buildings of that kind, into buildings where men spend the larger portion of their time when awake, and it has become of the utmost importance that buildings of this kind should have the subject of ventilation carefully considered in their planning. It is a good deal more difficult to properly ventilate an office building than it is other classes of buildings, for the reason that every square foot of office floor space is worth so much money; and when you get a building of eighteen, twenty, or more stories, you have got the structural shell and the enclosure to take care of, partitions, toilet rooms and the elevator space, and the owner finds it is a difficult problem to get back a return on his money that is satisfactory to him by utilizing every square foot of floor space that he possibly can. Therefore he hesitates about giving up any of this valuable floor space for what he considers useless ventilating flues. I know of several cases where a system has been carried out by two or three different methods. The question is as to which is the better one. When you undertake to plan a ventilating system in a very tall building you cannot make it very elaborate without abnormally increasing the cost, on which it is difficult to earn a return. The majority of men who rent offices for so much per annum ask for heat and light

and so much room; they do not ask for anything more than that; and further refinements beyond these that the owner puts in the building render it that much more difficult for him to earn a return on his investment, and office buildings are essentially investment buildings. There is an example in New York City of one building that I should like to speak of, in which our company were the contracting engineers, and Mr. Alfred R. Wolff was consulting engineer; that is, the American Cotton Oil Company's building in Beaver Street. It is an office building that is heated entirely by the blower system, and the steam supplied is taken from the street; there are no boilers in the building at all. In the rear of the basement there is a main fresh-air shaft that rises back of the building so as to get clean air. The air is screened, is brought down through this main shaft, and passed first through a tempering coil, then into the blower, and then over through the main heating coil, or through the by-pass; a double system of ducts leading to the base of all flues, and at the base of each flue a double mixing damper controlled by thermostat from the room which it supplies. This is going pretty far in office building ventilation, and it is difficult to get conditions where you can apply such a system. The hot and cold air ducts meet at the base of each vertical flue with the usual mixing-damper arrangement, and the air is discharged into the rooms. In all those rooms there is a system of out-going flues which lead to an aspiring tower, in which is located a large fan driven by an electric motor. This building has about 200,000 cubic feet of space in its offices, and the amount of air handled is approximately 14,000 cubic feet. This insures very thorough ventilation. The blower is driven by a direct connected electric motor, which has three speeds, 160, 185 or 190, and 225, if I remember rightly. The exhaust fan is also driven by motors with regulated speeds. This building gets a very thorough supply of air. It gets rid of the annoyance of the heat of boilers in the basement, the handling of coal and the dirt and ashes, and it is really one of the cleanest and freshest buildings that I know of. It is an ideal condition for an office building. It is something that ought to be followed in all office buildings and large institutions where they can control the whole building themselves, because it would insure their getting good air; and when you crowd a lot of men into an office, and

keep them from eight to ten hours, they ought to have good air. We go to a great deal of trouble in planning schoolhouses, where the children are kept in from nine to twelve and from two to four, with an intermission of two hours for freshening the building; but in an office building there are in some cases practically as may clerks wedged into a room as there are children in a schoolroom. There are rooms in the Western Union Building, the Postal Telegraph Building, the Pennsylvania Railroad Building, and others, where they have telegraph operators, and where the clerks in the car-record and other departments are as close as the desks in a schoolroom, and yet there is no provision made for ventilating those buildings as a rule; there is provision made in exceptional cases. I think it is just as necesary that people of larger growth should be taken care of in the matter of fresh air, when there is such an abundant supply outside, as it is that the children should be taken care of in the matter of fresh air; that there should be some special provision made for cases of that kind. In Philadelphia we have a building recently completed where another scheme is adopted. It is the Real Estate Trust Company's large office building, on the corner of Broad and Chestnut Streets. One section was completed a year or more ago, and the final additions have just about been completed, and are in use. There the air is carried up through three or four main vertical shafts in flues that are divided vertically, then those flues turn off to the ceiling of each corridor, and they carry horizontally along the ceiling of the corridors, false ceilings being placed below. They discharge into offices on each side of the corridor, through registers. The damper is located directly back of the register, and is controlled by a thermostat secured to the wall at the face of the register. The thermostat in the room opens or closes that particular register. That system has been extended to the new section. They have very large blowers in the basement. At first there was considerable difficulty with the wing on the corner of Broad and Chestnut Streets, it being much exposed, and complaints came of irregular heating. They are getting to know how to handle it a little better now, and the complaints are not as strong as they were at first. They have also made some changes in thermostats, which I believe has materially improved it, from what I have learned recently,

so that the system now is said by the tenants to be fairly satisfactory. The first complaint was that it was either too hot or too cold. They got too much hot air, and when the thermostat shut off the very small rooms, 9 x 12 or 13 feet, the change was so rapid, that they would get cooler air in there for a time, or they would get no air at all, and the room would chill very quickly, a condition which you can readily understand, when the room is so small and the window so very large, the building sixteen stories high, and exposed to the west wind. The corner of Broad and Chestnut Streets is notorious in Philadelphia as being the coldest corner we have, on account of the tall buildings forming a pocket. Those are two distinct systems I have described, therefore, for ventilating office buildings.

Now, a third one I was going to suggest is one that we have made plans for recently, in a dormitory building, not an office building, but it would apply equally well to an office building. That is to put a system of direct radiation through the entire building, to take care of the losses from the walls and windows, using box bases, direct-indirect radiators, carrying a series of small flues concealed in the walls, with high velocities from a blower, and discharging through small branch pipes under the radiator and through the radiator, making a system of direct-indirect radiation. But instead of cutting the walls or putting the boxes in the walls, which the architects object to seriously, we take the air direct from a series of small flues and send it in jets under the radiator, expanding it in a large chamber below the radiator itself into the room. That brings the air where you want it. The air coming up from the basement is tempered, and the additional heat is furnished by the direct radiator. This also has the practical advantage that before office hours or after office hours the blower is shut down altogether, and the temperature of the building is maintained during the night by the direct radiation; whereas the first two systems spoken of require the steam to be maintained at night in cold weather to hold the building to the required degree. This latter system is, I think, the more feasible one for the average building, because you can get but limited space, anyway, for vertical flues, and if you can put the air in at very high velocities and then expand it so as to reduce the velocity at the radiator, you are getting the amount of air in the room that

you need for the two or three occupants in an average office, and at less cost of operation and less original cost than the other and more complex systems described. In addition to that you give the occupant of the room the control of his temperature. He can shut off or leave on the radiator as he pleases. He can shut off the radiators, but he cannot shut off the air supply. The ventilation is through partition flues to the attic in the dormitory building we are planning, the usual aspirating coils. In one other case I know of, the ventilation is in the corridor of the building, the pressure being in the rooms, and the aspirating coils and ventilators are placed above the elevators, so that the elevators tend to form suction through the corridors. I think it is a field that has opened up for the heating and ventilating engineer, and I would be glad to learn what has been done by other men and in other parts of the country.

Mr. Barwick: The ventilation of office buildings can be done by another method. As a rule, in office buildings the ceilings are fairly high, and the corridors are narrow. By taking some central point, you can take fresh air from a shaft or from outside, and distribute that air through ducts placed at the ceiling of the corridors, discharging into the office rooms. In that way you can put a number of small fans where they will not take up any floor space. In laying out a very large building that was to be erected in this city, we designed such a system as that. The rooms were 20 feet high; of course they were very large rooms. We took up a portion of the corridor for heating and ventilation, placing the ventilation duct at the top of the corridor, and carrying our vent connections from the rooms above into that corridor duct, and then discharging the air at one point through fans. At another point we took in the fresh air, and distributed that through fresh-air ducts beneath the vent ducts, discharging into the rooms on the same floor as the vent ducts. In that way we could get a very large amount of air, and distribute it over a large area without taking up any floor space whatsoever.

Mr. Meyer: Mr. Jellett has raised the question as to the cost of the floor space taken up by flues for supplying a building with air. I think if you consider that a flue containing, say, 100 sq. ft. in cross-sectional area would perhaps supply a building ten stories high, and perhaps in the neighborhood of 100 feet

square. That would mean that on each floor 100 sq. ft. were taken by the flue. Considering that type of building which Mr. Jellett has described, distributing to the different flues from one main flue with branches, and exhausting through the hallways, in a building 100 feet square, the total amount of surface in it would be 10,000. The amount taken up by the supply flue would be about 100, which is only about one per cent. Of course, the cost of heating that way is another proposition. But it seems to me if they supply heated air in a school building and other places, there is no reason why they should not go to the expense of it in an office building.

Mr. McKiever: The third system that Mr. Jellett describes seems to be a very interesting system. I should like to ask if the system is in use, and as to the velocity it will carry in those vertical flues; and if, in those small orifices, when he is expanding his air, there is any noise from his system.

Mr. Jellett: The velocity in the side branches would be materially reduced as against the verticals, in the enlargement of the throat from the pipe itself. The velocity in the side branches would be practically about 800 feet; but if you take a 4-inch pipe and figure the area at a velocity of 800 feet into an office occupied by two or three men, you can figure where your ventilation would be. The volume of air in the room would be changed very rapidly. When it is expanded in the base below the radiator, it is further reduced. The system as described has not been carried out in all that detail as yet. It is now under contract in one or two buildings where we have made the plans for it, and we expect to have it in use completely before very long. In a modified form it has been in use. But it was an attempt to meet those conditions where ventilation is wanted at certain hours, and not continuously, and where heat is wanted at all hours to maintain the building at the proper degree, because it is the experience of all office building superintendents and managers that it does not pay to allow a building to cool off entirely. So they maintain the heat during the night to a reasonable degree, say 55 or 60 degrees. By having the direct radiation we do not operate the fan during the night; it is only necessary in the morning to start the fan at eight o'clock, or shortly before the usual occupants come, and begin to supply the fresh air, and cut it off at six o'clock. Under these condi-

tions the office building would be considered practically on the same basis as a dormitory, except that a dormitory is not occupied during the day, but is at night.

Mr. Bolton: The chief difficulty in ventilating an office building lies in the venting or eduction side of the matter. The supply of air to a building does not need so very much consideration, because there is a natural ventilation through these very tall buildings, which increases very much with their height. In most of the large buildings that have open central elevator shafts, a draught sets up from the hall through the elevator shafts, and into the offices through the transoms if they be open, even if windows are closed; but it also occurs that objectionable smells thus find their way into the offices. Again, as soon as there is a wind pressure from one side or the other of the building, it is remarkable how much air finds its way up through the centre of the building in a rough sort of fashion. In fact the general inward leakages are among the serious difficulties met by heating engineers in tall buildings, and they increase in proportion as the height increases. The most practical difficulty that has really arisen in inducing owners to adopt definite ventilation in the tall buildings has been the misunderstanding on their part of any value at all in ventilation, which point Mr. Jellett has brought out very clearly. They really look upon it in that way—that it is not a rent-producing item. They have nearly all of them had relations with real-estate agents who uniformly belittle any such item as that of ventilation and will bring up any number of experiences of theirs with different tenants who do not want ventilation, or who do not like ventilation, or who object to certain temperatures. It is quite true that some want less and some want more, and any fixed scheme of ventilation and heating combined is apt to be very much complained of by a certain class of cranky tenants. It is well known in office-building work that when your tenants come in you must change radiators around to a great extent to satisfy them. Some people do not seem to be satisfied with the ordinary ratio of heating surface to contents, and it seems as if they wanted to be almost broiled. They prefer the conditions of tropical animals in the Zoo, and seem willing to live in that sort of smell too. Another difficulty met with is in the changing of the divisions of an office building. A great many office buildings are

plotted out with rooms divided up on a typical plan, but it is rare that that typical plan is entirely followed, and in a large number of cases the rear of rooms is divided from the front by partitions, making little rooms at the back, where typewriters are kept, and the partitions interfere with any scheme of ventilation from the corridor of the building. Such difficulties have to be overcome before you can introduce any general scheme of heating and ventilation combined. To my mind the way in which this problem should be dealt with is by placing direct radiation through the buildings, of such an extent and character as will be amply sufficient to maintain the building at a fixed temperature and afford the reasonable heat which some of these people that I have mentioned require, and then providing a fixed supply of tempered air into every set of rooms, at a fixed temperature which nobody can complain of, say 70 degrees Fahrenheit. Now, if you have tenants, and there are many such, who object to ventilation, they could shut off the air supply, and live in gas, or anything else they like; but if you depend on the supply of air for heating too, you will be apt to have trouble, because they will shut that off and forget it, or else complain of draughts, and the room is not heated.

Mr. Meyer has brought out a point that should be insisted on with the architects of such buildings, and that is, that the question of ventilation is a very small item in comparison with the rentable value of any floor in a tall building, and it is very difficult to get them to provide anything in the way of space for such a purpose. I have offered to make use of the same shaft in which the elevator cylinders are commonly placed nowadays, but even that is sometimes denied. It is even difficult to get them to provide a ventilating shaft for the line of toilets in some of these buildings, and when they do so they generally expect that such a vent shall have to work on its own account. They place a lot of registers in it and expect that the natural levity of the air is going to work the ventilation. When it works the reverse way, as it frequently does, they put a heating coil at the bottom, and thus drive the air up and through the registers into the rooms half way up the height. Ventilation in office buildings is really a matter that largely lies in the hands of tenants who are paying so many dollars a square foot to be shut in a more or less air-tight box all day long, and who are

certainly entitled to their modicum of free air while they are doing their work; and when those tenants get around to the point of making a hue and cry and demanding their sanitary rights, I think that owners and architects will be driven to consider them, and there will have to be some very tall thinking done then, to get ventilation into some of the existing tall buildings.

Professor Kinealy: I was recently discussing this subject with an engineer and he told me of an unusual kind of owner. He said that he had been asked by a man who was putting up an office building to lay out the heating plant, and this man had figured out, to his own satisfaction, that the flues for the hot air for heating the building and for cold air, so that the air entering the rooms could be tempered, would occupy less space and would therefore cost him less yearly than would the space occupied by the radiators, including the cost of changing the radiators as the office rooms were partitioned off in changing. I do not know his figures, so that I am unable to say exactly how he arrived at his conclusion, but it struck me that there might be something in it; how much I don't know. In this particular plant, however, the system was laid out with two sets of ducts in the corridor of each floor, and over the door leading into each room there were two flues, a cold-air flue and a hot-air flue, and the occupants of the rooms regulated the temperature of the entering air to suit themselves.

Mr. Jellett: I should like to add a few words to what I have said in view of Prof. Kinealy's reference to the unusual owner. Two years ago I was consulting engineer for a large office building erected in Philadelphia, twelve stories high in one part, nine stories in the other. The first floor is a store, the second floor rear is an assembly hall, the balance is an office building. There is a blower system for heating the store. There is a separate blower system for heating the assembly hall. There was originally intended to be a third blower system to handle the offices. This system was planned and the building committee had given their sanction to the arrangement, until one day at a committee meeting the chairman said that he had been looking up the question. He said, " I believe in ventilation and am ready to spend the additional money needed for the ventilation of this building, if the people who are going into it appre-

ciate it; but I have gone around and made some very careful investigations, and I find when a man comes into an office and finds it too warm he never thinks of the register provided—he throws up the window or lowers the transom. If he comes into the room and finds it cold, he sends the office boy to see the engineer and find out why there is no steam on." He said, "I have been investigating this thing very carefully and the fault is not all with the owner. Here is our building committee perfectly willing to spend the money, but we have not five or six or seven thousand dollars additional to throw away if the tenants are not going to appreciate it, and the result of my personal investigations leads me to believe that they won't use these appliances if they are given to them." There is the other side of the story—the owner in that case putting the responsibility on the tenant—and by resolution of the committee they instructed me originally to put in the ventilating system; and afterwards they instructed me to put in plain direct radiation in the office portion, and put in the blower system in the assembly hall and the store.

Mr. Cary: In the last case mentioned by Mr. Jellett, supposing he had in use one of the other systems he formerly referred to, with the thermostatic regulation, would there be that rushing for windows or transoms to open them? There would be no necessity for such actions under such conditions. Further, with such regulation, would it be necessary to keep a boy to run up and down stairs to find the engineer? I think that such an argument might meet the objections brought up by this committee.

Mr. Barron: I hope Mr. Jellett will sum up, and I should like him to give a little attention to thermostats when he is summing up, because there is a gentleman here who represents thermostats very solidly. I have been in buildings where Mr. Jellett was engineer and I know the thermostats were not in use. I have been in some buildings in Chicago where the thermostats were applied but not in use—office buildings in both cases. I should like to know how the thermostat to-day is working with Mr. Jellett.

Mr. Jellett: Mr. President, I do not know that that is a fair question. I never complicate a mechanical system if I can find any other way out of it. That is the broad statement in

answer to anything of that kind. I have put in the thermostats in certain classes of buildings. I have regretted afterwards that I put them in, because everybody tampered with them and had them out of adjustment, and they were a source of continual complaint. But the development of the thermostat has been going on. People are getting to understand now a little better about them. Our first trouble was that they would not leave them alone. We have one private house in Philadelphia where we have never had a complaint from the thermostat system since the time it was first installed. It was one of the earlier ones. The reason is that they leave it alone. I equipped three buildings in the University of Pennsylvania with them, and they were thrown out inside of two years, because they were voted to be an eternal nuisance. The boys would short-circuit them and do all sorts of things. Electric detectors were rigged up on them, but the boys were posted and were not to be caught, and after spending $5,000 to $10,000 on them, the superintending engineer told me that he had taken every one out, and there are not going to be any more in the University of Pennsylvania while boys continue to be what they are. He would need to keep about two men employed constantly to keep them in condition. He said if they could be fixed in such a way that they could not be tampered with it would be all right. "But," he said, "I have not found a thermostat yet that cannot be tampered with by a lot of healthy college students." There are a great many other cases, in schools and places of that kind, where there are systems of indirect heating, where you can place your thermostats in the basement and control your dampers. That is really the only satisfactory way to apply a thermostat. A thermostat controlling radiator valves in the average building occupied by students or school children or others has proven very unsatisfactory by reason of tampering. Thermostats applied at the base of the flues in the basement, where you have an entirely indirect system, have given good results, because they are in charge of a competent man. We find another thing—the average fireman or engineer will not go out of his way to take care of them. The majority of engineers do not want things that involve additional care, and it is the hardest thing in the world to get these men to give proper attention. I took that question up

only about two weeks ago with the chairman of the building committee of a church. We put in a plant a couple of years ago. They had considerable trouble with it when we started it and for some little time afterward. They said the ventilation would not work. I would go out there and find steam was not in the aspirating coils; put it on and then the ventilation worked. The next time I went out the church was cold at the half-past ten o'clock service. I went down and found the damper turning all the air into the Sunday-school. I told the committee finally that if they wanted me to run the plant as well as to construct it, I would do it; but if I put a man there they would have to pay for him. About two weeks ago I was in the same building. The chairman said to me: "I have reached one conclusion on blower systems and ventilation systems, and that is, that the more you go into elaboration and refinement in heating and ventilation, the more intelligent must be the man who takes care of it, and we are acting on that line now and we are having no trouble. The man that has sense enough to shovel coal in a fire door of a boiler is not the kind of animal that wants to run a modern heating and ventilating plant in which care must be employed to produce results." I think he is right. We want to educate the engineer too.

TOPIC NO. 2.

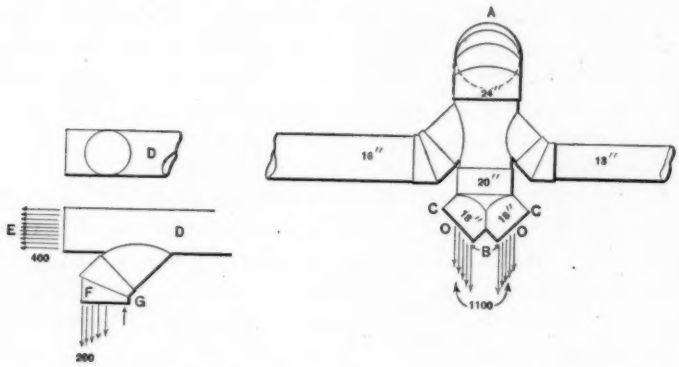
"What should be the velocities in the main ducts and branches in a forced blast system of heating, with a capacity of moving 25,000 cubic feet of air per minute, also in the air-supply ducts?"

Professor Carpenter: It seems to me that one may have a good many notions on this subject, and I should expect that different engineers would answer this question differently. It seems to me the whole thing depends on how much loss of heat we are willing to stand. I think very good practice is to keep the velocity of the air in the main duct 30 to 50 feet per second on 1,800 to 3,000 feet per minute. I should like to reduce it to about 10 feet per second in the supply ducts. That is simply, however, a question of practice. If one wishes to have more pressure on his fan and more loss of heat due to friction in his pipes, he can make that velocity what he chooses; but in laying out special plants I have worked

to the figures as above, and the results have been quite satisfactory. I can understand how other velocities also might be satisfactory, and I know very well that some engineers proportion pipes for a considerably lower velocity. In regard to the velocity of the air coming into the room, I should like to have the registers large enough so that it shall not exceed five feet per second. Perhaps I am conservative in this notion, but it seems to me a good safe velocity to select, although there is not any doubt in my mind that higher velocities at times would answer every purpose. I know also that a good deal lower velocity than what I have spoken of is frequently obtained in the main supply pipes. I have known pipes to be proportioned for one-half that velocity, and I think in one particular case at one-fifth of that velocity. The only objection to this practice, of course, is the expense of the pipes and the room they take. If you can stand that expense and can spare the room I should think it was good practice to keep the velocity low.

Mr. Barwick: I should like to ask the professor if 3,000 feet velocity is not rather high—if there is not a swish of air passing through the ducts under that velocity? I find that with 2,000 feet velocity I get a swish of the air. That is objectionable in a great many places. Take school buildings, for instance; I find that a velocity of 2,000 feet from the fan into the main ducts, then reducing to 1,500, then to 1,000, and gradually reducing to the verticals at about 500 to 600, is really the best practice that I have had. Through the registers I deliver at about 300, or from 300 to 400 feet per minute. I find in a great many cases that we cannot locate the registers in a proper position, so as to get good results with a low velocity. If we have 400 feet velocity there will be a draught generally felt, although we place the registers as high even as 8 feet to 9 feet, and in some cases 10 or 12 feet. I notice in this room that they have placed deflectors so as to minimize the velocity. I do not know what they are delivering in this building. I know that we have to place deflectors in a great many class-rooms; Mr. McMannis has found it especially so in New York City schools. In factory work I have delivered air into the rooms at 1,000 feet velocity without any trouble. I have carried as high as one ounce pressure on my fan. That gives a velocity of a little over 4,000 feet, and I have carried branches and

equalized the outlets down to 300. I generally taper my branches in proportion to the outlets and velocities. I found in one building, that was erected by others some time ago and I tested, a peculiar thing which I have no doubt many of the members have seen, and I will just make a little sketch on the board. That (referring to sketch) A is a five-piece elbow. I will make a plan of it. There was a velocity of 1,100 in A. At B I received a velocity of 1,100. This outlet point was 20—18—18. At C point I received zero. I took another test of one of similar construction to D, and there was a long run of



18-inch pipe. The velocity was about 400. This was 16—16—16. Here the velocity (F) was about 200, while at G it was reversing.

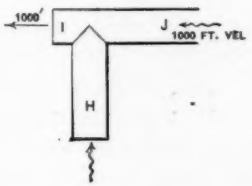
Professor Kinealy: How long were those branches?

Mr. Barwick: This pipe was about 54 feet long.

Professor Kinealy: Those branches—outlets?

Mr. Barwick: These outlets were just simply a mouthpiece about 6 or 7 inches. The condition at B was, that the air was flowing and just divided itself in a line, and the same way C received nothing. At that point G there was practically a suction, or a well in there. In another case I had a vertical flue H connected to I and J. The velocity at I was 1,000 feet; 1,000 feet at J, and at H a suction. I believe that it is much better to reduce the velocity in vertical flues, so that there shall not be over 500 or 600 feet velocity if it is possible, and when we branch from our ducts with higher velocities, to reduce the

areas by contracting the openings into the flues, or into the outlet pipes as much as possible, so as to equalize the whole system, and I found that where we have done that, we have had very good results. The plans that Mr. Jellett had here yesterday were made by Mr. Wolff, and the ducts and branches were reduced in that manner. In testing all of the registers I found very nearly every one of them about 400 feet velocity, holding the anemometers very close to the register, and following the course of the register in spiral form until I reached the centre; and we had pretty even distribution all over the register. The velocity into the main duct is about 2,000 feet, and those are velocities that we have generally used. I try to have my fans large enough so as to reduce the velocity, if possible, to equal a quarter-ounce pressure. I have proportioned my tempering coils, allowing a large free area, so that the friction



is reduced to a minimum, with the air passing through them, and I have got very good results with very small horse-power. I think that structural conditions have a good deal to do with the velocity of air in pipes, and they should be proportioned with proper care in every case. I think you can use high velocity in factories, but in school work and office buildings, and hospitals, etc., very low velocity should be used. I have found that if the ducts are not suitably constructed and of proper strength, or properly braced, there will be a wabbling and banging, if the air is under very high velocity, and therefore we generally use very heavy gauge iron, brace them thoroughly, and try to keep our velocities down to as low as possible so as to reduce the noise and swish.

Professor Carpenter: Mr. Jesse M. Smith, a prominent mechanical engineer, is with us to-day, and he wishes to say something regarding the difficulties they have had in the venti-

lation of this room. Mr. Smith, I think, has given it considerable study, and I move that we invite Mr. Smith to speak to us.

The Chairman: I think there will be no objection to giving Mr. Smith the privilege of the floor.

Mr. Jesse M. Smith: This question is quite a delicate one with me, because I happened to be on the Committee of the Mechanical Engineers that has charge of the heating and ventilating of this house. Your society coming into this room will, of course, notice that the ventilation, or the putting of air into the room, is very defective. You feel draughts, although there is not a very great amount of air coming in. I want to say that our contract for this ventilating system calls for the introduction of air without appreciable draughts, and that the contractor still has the plant on his hands. The contractor made his own plans and was given *carte blanche* to go ahead and do what was right, and he has not yet succeeded. But I want to say that when the air that is supposed to come through these four flues in the corners is in amount equal to that provided by the contract, the average velocity should be 625 feet per minute, and that the outlets when they were originally covered by the register faces were about the same area as the pipes, so that the average velocity through the radiators should be at that rate of 625 feet a minute. But when the register faces were in place, we discovered a very peculiar state of affairs; the lower part of the register face was entirely inert. All the air came through the upper part of that area. Extending from each lower corner up to nearly one-third the height of the register, there was a triangular area through which no air flowed; whereas at the top of those openings, the velocity was considerably higher, and in order to make up the average of 625 feet, it was necessary that the velocity at the top should be very much in excess of 625 feet a minute. Now, I am not a heating and ventilating engineer in any sense of the word. I am merely a mechanical engineer, and my work has been in other lines, but I was unfortunately made a member of this committee, and since this query has come up I am very much interested to know the views of this learned body on the subject, and should be very glad to have more enlightenment, so that the next time you have your meeting here this room will be venti-

lated in a proper manner, not only as to the temperature, but as to the purity of the air.

Professor Kinealy: I have made a great many experiments to determine the velocity of air coming through registers, and I found exactly what Mr. Smith has said he found; that is to say, that the lower portion of the register in a flue, such as the one here, is either dead, or has what I call a negative flow; that is, the air flows in. Now, the distance above the bottom of the register at which the air would begin to flow out would be very nearly equal to the distance from the vertical part of the flue to the face of the register. That is really the register that you have; in fact it is less than that, because you are taking in air at the bottom here which you have to discharge at the top. Now, in ducts such as have been described this will always happen, and it is absolutely necessary where you have short openings, that is, when the branch pipes leading from the mains are very short, if you want to get anything like a low velocity, or an equal distribution, to put in a volume damper, and that volume damper will require considerable adjustment before you get anything like equal distribution. The higher the velocity through the horizontal pipe the harder it will be to get an equal flow through the branch. I think that the velocity you should have in ducts, either in the main duct or in the branch duct, depends very largely upon circumstances. You can have a greater velocity in the branch duct, and through the register, where the register is above the floor, and the wall of the room opposite to the register has a great deal of glass surface, and is at a considerable distance from the register. If the room is narrow and you are forcing air in from one side at a high velocity towards a comparatively warm wall on the other side, you get down-draughts; the air simply goes over and then down. But if the wall is some distance from the register face you don't have such trouble. They employ very high velocities in factories and do not get anything like the trouble that we have in small rooms with high velocities. Of course, where the air is introduced near the floor, as is done in some places where they use the air simply for heating rather than ventilating—that is to say, the building is treated exactly as though a furnace were used to heat it, and the temperature of the room is regulated by opening and closing the register—in that case the air

is brought in close to the floor and you have to use very low velocities through your register. The use of high velocities in the main ducts means, of course, small ducts, and that means low first cost; but it means high pressure against which the fan is running, and that means a continued use of more power than would be necessary if lower velocities were used. Of course, the higher velocity also means more friction and more loss in the ducts. What is the best velocity, is, I think, a hard question to answer. It does not make any difference whether it is 25,000 or 50,000 cubic feet of air that you are handling, each problem has got to be treated to a certain extent by itself. However, I think a velocity in the main of about 1,500 feet will give pretty good results, and a velocity in the branches in the neighborhood of 600 will do. But your branch has got to be of some length in order that when you take the air at the high velocity from the main duct into it, the air will have begun to reduce its velocity and acquire the velocity for which the branch is proportioned before reaching the register.

Mr. Payne: To overcome the difficulty that has just been spoken of, I have seen a method employed like this (making a sketch on the blackboard). These division lines are carried down a certain distance so as to divide the currents, and so cause a more equal flow to the register.

Mr. B. H. Carpenter: I have seen that same thing, and we have tried it ourselves. But I do not think it necessary to run the deflectors as far as shown. In fact, I was surprised to see how short the deflectors could be to make a very perceptible difference. Putting the fans, or whatever you might term them, in a couple of inches, just so as to strike on the inside of the flue, and make each one of them longer than the next, I think is better than dividing them up, as shown, and running them down into the ducts, because the pressure through the duct is not always equal; and as shown it would tend to carry the air through the same opening in the register that it has in the duct. We have found the same results as several have spoken of, that there is often a negative pressure at the bottom of the register, and the negative pressure is generally described in a circle on the face of the register, very much as the professor has stated. The circle starts at about the same distance from the bottom of the register as the face of the register is from the flue. We do

not run as high a velocity, generally speaking, as has been spoken of. We seldom have the air coming from a register at more than 400 feet per minute, especially if it is in a room that is pretty well filled. In a schoolroom, for instance, we seldom have the entering air coming in at over 400 feet, and often much lower, and we are not troubled with draughts. One church auditorium, which was quite a difficult problem, was described here a year ago. We bring the air in at the ends of the pews, the aisle being five feet wide, and the air is driven toward the aisle. The air is brought in at not over 200 feet, hardly as much as would be gotten from the gravity system. But it was divided up in a great many registers.

Mr. E. P. Sparrow: The trouble experienced in ventilating this room reminds me of a somewhat similar case that came under my observation regarding the ventilation of a theatre. In this particular case the air was introduced through the ceiling and side walls under the balconies; the air entering through the latter ducts caused very disagreeable draughts, which could be detected even as far down as the stage. The contractors tried various forms of latticed deflectors, which only partially overcame the difficulty, and it became necessary to close these openings entirely, with the result that the air under the balconies would get so hot and foul that it was almost unbearable.

I suggested to the owners that the register faces be removed entirely, and that plain deflectors be placed in front of the openings, and about twelve feet from the wall.

The result more than fulfilled my expectations, and in place of a system that had been pronounced a complete failure, the theatre is now considered one of the best ventilated to be found anywhere.

Mr. Barwick: I should like to ask Professor Kinealy and Professor Carpenter if they have ever made tests of the difference of temperature of the air passing from the fans through the outlets; that is, taking the temperature of the air at the fans, and then the temperature, say 50 feet further along, have they ever found a ratio by which they could figure the loss in heat units by radiation of the ducts from the air travelling that distance?

Another thing, I should like to know just what conditions

(if they have made such tests) they found of the air in the room, whether or not there were draughts.

Professor Carpenter: In regard to the last question, in two cases we have made some measurements of temperature similar to that Mr. Barwick refers to. In the first place, we found a great irregularity in temperature at various points in the cross-section of the duct in each position. In making these measurements we have to divide the duct up in each case into a large number of small squares, and we took a measurement of temperature in each one of these, and obtained the average. The irregularity is very striking. If I remember rightly, in a paper which I presented some three years ago on a test of heating and ventilating of the New York State Veterinary College, I gave some temperature measurements as an illustration, showing this irregularity. There is a fall of temperature quite frequently in air ducts, which is entirely dependent upon the expansion of the air in the ducts, and which is a troublesome matter in itself to account for; because unless we do account for the expansion and the consequent increase in velocity it is rather hard to explain the temperature variation as shown in the two places. So far as the tests are concerned, we have found no great difficulty in getting a pretty good heat balance between the heat given off by the steam in the coil and the heat measured in the air. Last year in making a test of a new heating plant in the Chemical Building of the University, the results of the measurements taken from the anemometer, uncorrected, showed considerably over 100 per cent. efficiency. We had, I think by these measurements, 120 to 130 per cent. more heat in the air than in the steam. When we came to calibrate the anemometer, substituted the corrected results, our final heat balance was very reasonable. I do not remember the figures, but it came out just as it should. I am getting to believe that no more unreliable instrument has ever been sold than the anemometer. It may read perfectly correct one month, and the next month some little thing may happen to it which perhaps is not perceptible, and it may read very much out. The error with anemometers seems, as shown by our experience, usually to favor the man who puts in the heating apparatus. I do not believe we have had a single case where they have read too low, but some of the readings are much too high.

Mr. Barwick: What I meant was, isn't there a loss from radiation? Couldn't that be measured?

Professor Carpenter: There is certainly a loss, but it is not large.

Mr. Smith: When the contract was let for ventilating this room there were three bidders, and they all furnished their own plans, and all three of them provided for four ducts in the corners. There was never any request from any one of the three bidders to carry the flues above the gallery, and there was never any thought of it. That question arose after the trouble due to a draught was discovered later, and then in seeking a solution of the problem it was proposed that the flues might be carried through to the upper story. That was objected to by the committee of the Mechanical Engineers, for the reason that it took away from our shelf-space in the library, and also that it delivered the hot air on the books, where we thought the air would be damaging to the binding. I want to say that there was never a question of carrying the air above this gallery until after the plant was put in.

Mr. B. H. Carpenter: I think if the ventilating is supposed to be done at the floor line it would be overcome to some extent by putting in these deflectors, and driving the air up in flues, if there would not be a whistling noise from the speed of air against the deflectors.

Mr. Barwick: I have an audience room at the present time under my care, in which the air is delivered at three points; one on the north side, one on the east side, and one on the west side. The opening on the west side has an area of about 5 square feet. The one on the north side has an area of about 4 square feet; the other has an area of about 2½ square feet. Unfortunately the air travels in one a little faster than it does in the other two. The air currents meet at a common centre where it falls, and I had the complaint that a party had felt a draught from it. I will place a deflector in one of these, which will give better results.

Professor Carpenter: I am going to make a suggestion which is not exactly in the line of the topic discussed, which refers to the four registers used for admission of air to this room, and to get an expression of opinion, if allowable. It may perhaps be remembered by the members of the society that at the time

I presented the results of the tests of the State Veterinary College, there was considerable discussion over the result which we obtained from the distribution of air in the main lecture room. If you remember, the paper gave the velocities in different portions of the room as actually found. You may perhaps recall that the distribution was bad. It could not have been very much worse. The room is perhaps about the size of this, but a little wider, and possibly a little more nearly square. We had in that room at the time the test was made four registers, and admitted air into the room from four points; in studying up the problem of distribution, it seemed to me that the results were made very bad by the eddy currents, formed by the currents from these different registers meeting; we afterwards cut out two of those registers, and admitted the air in two points only, with the result that the ventilation has been very much better, the draughts less, and very much better controlled. I have thought that with a room of this size, the air currents possibly could be distributed better from two points than from four. That was the only suggestion.

Mr. Smith: Mr. President, will you allow me another word? Before the bids were asked for, for the ventilating of this room, we had a consultation with the engineers who proposed to put in the bids, and it was suggested at that time by some members of our committee, that it would be possible to bring the air into this room at two points only, and it was suggested that those two points be in the back of the room, forcing the air toward the front and carrying out the foul air through the risers in the steps of the platform, as it is carried out now. Three of the bidders, representing very excellent ventilating houses, said that it would not be practically possible to bring the amount of air that we required in this room through two ducts, and they all requested to be allowed to put in four ducts, and they did put in four ducts. Now, these three representatives put in their bids independently of each other, each one furnished his own plans, and, as I say, all three of them provided for the four ducts. Now, of course, those were men of experience. They are doing this kind of work every day. It is their business to do it, and the committee thought the unanimity of opinion as to how the air should be brought in, by these three men of experience, was rather remarkable. Now, the result is we get these draughts,

these cross eddies. There are points in the room where you feel a great deal of draught, and other places where you feel none. The velocity of the air entering is not anything terrible—625 feet on an average, and the lowest velocity that has been spoken of here, for the permissible velocity of entering air, is about 200 to 300 feet—still we get these focus points of draught in the different parts of the room, and it would seem to be quite reasonable that those four currents coming from the corners, meeting in the centre, would naturally, drop down on our heads, and that seems to be the result. But it is the result of the thought of three disinterested and separate minds, furnishing three séparate plans for ventilating this room, and it seemed to be so unanimous that the committee of the Mechanical Engineers thought they were entirely safe in accepting one of those plans. Now, if there is any way in which those draughts can be prevented, so as to make not only the members of your own Society comfortable here, but also the members of the Electrical Engineers and Mechanical Engineers, who also occupy the same room, it would be a great advantage to all of us to know how this plant can be made to work so as not to produce any disagreeable draughts.

The Chairman: Does any other gentleman wish to speak on this subject?

Professor Kinealy: I want to say just one word. It is a matter of surprise here to listen to what has been said in respect to the ventilation of this room—that members of the American Society of Mechanical Engineers, many of whom are consulting engineers, should ask a contractor to plan a system for nothing, and pay him only if his plan is accepted. (Laughter.)

Mr. Smith: If I may be allowed to reply to that, our committee offered these gentlemen a price for their plans. The proposition was that we should pay these three different parties a certain amount of money for their plans, and that when we had those plans we should select the one which suited us best, and that then the obligation should cease. Unanimously they said, "No; we will furnish these plans ourselves, and if you don't accept the contract the matter ends there. We prefer to make our own plans. We prefer to be responsible for the whole job. All we propose to do is to ask for the money when the job is finished and the work is carried out according to the contract."

The committee said, "We want results. We have the money to pay you. Make a plan and put it in."

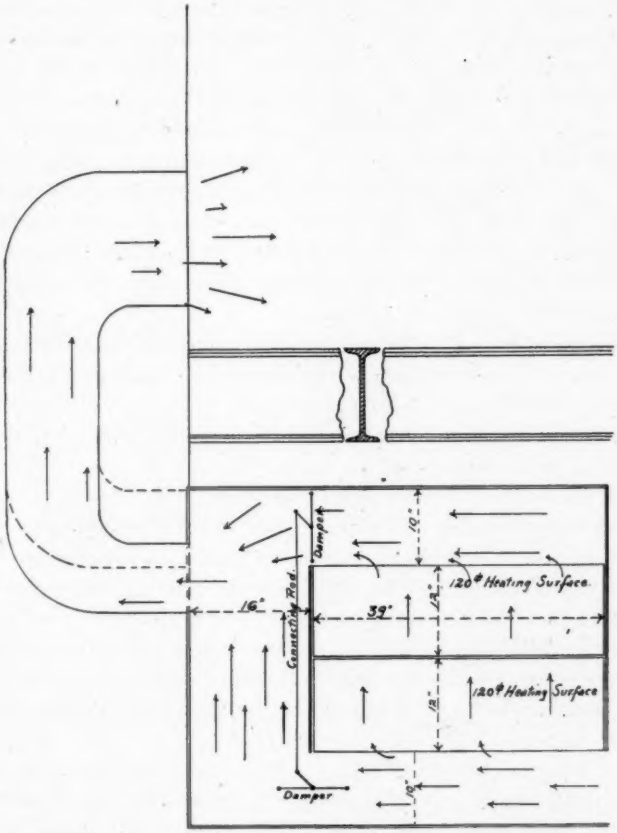
TOPIC NO. 3.

"Is there any advantage in a gravity or fan system in taking the heated air from an indirect radiator casing at a lower point than the top of the casing?"

Secretary Mackay: Mr. President, I would like to talk on that subject for a minute or two, in connection with low pressure gravity apparatus. It has been contended that there should be a certain space below and above an indirect radiator, and the common practice has been to take the air from the highest point, and so arrange the casings that the air would pass over as much of the surface of the radiator as possible. The same thing applies to the indirect radiator as to hot-air furnaces. It has been found that an air chamber above the furnace is a necessity and an advantage, and the best results in taking lines of hot-air pipe from such a casing are obtained when the pipe is taken from the highest possible point of the casing. I was called in during the past summer to consult with the engineer and commissioners of a penal institution. There are thirty-two indirect radiators in use at the present time, but there will eventually be four times that number. There were a number of mistakes in the designing of the plant, due largely to lack of time given the engineer to prepare plans. But we agreed as to the necessary changes in every point, except one. That was the arrangement of the indirect radiation. I have the architect's drawing here and an enlargement of it.

The hot-air pipe led from the indirect stack to the room above. The stack was in a large plenum chamber. The height was about twelve feet, so that the head room did not come into consideration at all. The air was admitted at the bottom into the galvanized casing. The space above the stack was ten inches, and the space below ten inches. The top of the outlet was seven inches below the top, leaving only three inches between the top of the stack and the air cushion, as I would call it, above. The architect and the engineer claimed that there would be comparatively no difference in the operation of that radiator with a three-inch air space above it, or with a ten-inch

air space. I contended that there would be considerable difference, and I felt that I would like to get the opinion of some of the members upon that subject.



Indirect radiator casing and hot-air connection. Solid lines, show faulty; and dotted lines, proper connection.

Mr. Kent: Will Mr. Mackay explain what the difference would be? I do not exactly understand.

Secretary Mackay: I claimed that the proper point to take that air was from the highest point, and they agreed with me, but they claimed that on account of the cost it would not pay to alter it and that the difference in results would only be slight.

Mr. Kent: Is the casing filled with indirect radiating surface?

Secretary Mackay: These are two stacks of indirect radiation. There are two indirect radiators. The outlet was dropped down seven inches. Consequently, if there is any advantage in an air space above an indirect radiator, they lost the advantage in not being able to use it. They had an air cushion of seven inches there. It was a question of whether that would make a fractional part of one per cent. in the operation of the radiator, or a larger per cent. While this is not in practical operation yet, I have had experience along those lines where a radiator five feet long, of twenty sections, had a three-inch air space above, and a three-inch air space below, and it made a difference of about fifteen per cent. in the operation of the radiator, when it was reconstructed with a ten-inch air space above and an eight-inch air space below the radiator.

Mr. Connolly: Don't you think if that three inches was cut off, and it was made funnel shaped you would get a better delivery on your first floor discharge?

Secretary Mackay: I claim that the connection should be taken off at the highest point.

Mr. Connolly: Not necessarily sloping at all.

Secretary Mackay: Sloping would be an advantage. An architect who is putting up one of the costliest buildings in New York said it did not make the fractional part of one per cent. whether you had a three-inch or a ten-inch air space above the radiator. What object is the seven-inch space above the radiator if it is cut off? I claim it retards the flow of air, causes friction, interferes with the working of the apparatus to a marked degree.

Mr. Kent: The object is this. That if you did not have that seven-inch space there, there might be a choke in the air going through the three-inch space; while taking the choke away there is a little more freedom for the air to get through.

Secretary Mackay: That is working on a slight pressure. What I suggested was the lowering of all the stacks down to a point where the casing would allow it to travel upwards.

Mr. Kent: I do not think there would be any great objection to that, provided you had no choke there. There may have been a choke at the damper.

We have that problem sometimes in chimney flues. It is

not infrequent to have chimney flue come along, then dropping down on account of some obstruction, then going up. The only objection to that is considered to be the friction of this extra distance, and the two right-angled bends. The objection is extra friction going around these bends. The up-cast current balances the down-cast current here.

Secretary Mackay: I would say that my statement was made on the experience of tests under similar conditions. You have to accommodate yourself to circumstances, and the circumstances did not exist here. It was merely a matter of mistake in the engineer's plan, and a question of whether that mistake was worth $300 or not.

Mr. Barron: If it is not imposing on you and on the others here, I would like to hear Mr. Blackmore on that subject; what his general opinion is.

Mr. Blackmore: I thought that the thing had been pretty well threshed out. It is wholly a question of friction. Undoubtedly, as the arrangement is shown here, there is a little more friction. If the plenum conditions were sufficient to overcome that friction no harm would result. If it was purely a gravity system I should say it was very defective. With a plenum condition behind it, I believe no serious trouble would come from it.

Mr. Connolly: The plenum was nothing more than what an ordinary cold-air box would be. A good northwest wind would be better than a plenum.

Mr. Blackmore: I do not think the heated air dropping down is the serious matter in the problem. The question is how it dropped down, as Mr. Kent put it. If it is dropped down by an easy slope, it could be easily overcome.

Mr. Barron: I would say that Mr. Mackay's contention is perfectly right. I am surprised that the architect should really dissent from that opinion of Mr. Mackay's.

Mr. Kent: If you will allow me, I would like to make answer to this question: "Is there any advantage or disadvantage in a gravity or fan system in taking the heated air from an indirect radiator casing at a lower point than the top of the casing?" I would say that on general principles, it would be an advantage if you could take the air from the bottom of the casing; that is, if I were designing this, I would put the inlet at the top, and

the outlet at the bottom, for this reason: that when you have a large stack of radiators, and you are passing air upwards through them, there is a tendency of the air to short circuit, while if you put the air on the top of the radiator, the air does not want to go down at all; it will flatten itself out, and all the heating surface will be affected. How much there is of that I don't know, because I do not know of any tests on the subject.

Mr. Blackmore: That would necessitate, of course, a plenum condition.

Mr. Kent: Yes, or an exhaust condition at the other end, something to pull the air down.

TRANSACTIONS

OF THE

FOURTH SEMI-ANNUAL MEETING

Chicago, Ill., July 12-13, 1901.

LXXXV.

THE AMERICAN SOCIETY

OF

HEATING AND VENTILATING ENGINEERS.

FOURTH SEMI-ANNUAL MEETING.

Chicago, Ill., July 12–13, 1901.

PROCEEDINGS.

FIRST SESSION.

The meeting was called to order by the president, Prof. J. H. Kinealy, at the Victoria Hotel, Chicago, Ill., at 2 P.M., on Friday, July 12, 1901.

The President: The first business is the roll call. The secretary will please call the roll.

The Secretary: Before calling the roll, I would announce the following persons have been elected to membership in the society:

LIST OF NEW MEMBERS.

ENOCH RUTZLER.	FRANK P. BLODGETT.	CHAS. R. BISHOP.
GEO. B. ENGLAND.	AUGUST KEHM.	ALFRED S. HAMLIN.
WM. K. DOWNEY.	HENRY B. GOMPERS, Associate Member.	

The secretary then called the roll.

The President: This, as you all know, is the first meeting that this Society has held in the West, and I am sure that you feel, as I do, very gratified at the attendance that we have here.

The programme shows a number of interesting papers, and we have also a number of topics for discussion. I hope that all of the members will participate freely in the discussion of the papers, and will also talk freely upon the topics; and I want to invite all of our visitors to take part in the proceedings, by discussing the topics and papers.

The next order of business is general business.

The Secretary: I have here a letter from William Robert Maguire, president of the British United Heating and Ventilating Engineers, and member of our society, inclosing an invitation for the president and secretary to attend their dinner and address at their annual convention, on July 23d and 24th, in Dublin.

The President: The secretary will, of course, acknowledge the invitation and we will be present in spirit if not in body. We will proceed with the programme. I will ask Professor Carpenter to read his paper on the "Effect of Circulation on the Capacity of Fire-box Heating Surface."

Professor Carpenter then read his paper, which was discussed by Messrs. Blackmore, Hibbard, Morgan, and Mackay.

The President: The next paper is "Hot Air Furnace Heating," by Mr. C. G. Folsom.

Mr. Folsom then read his paper, which was discussed briefly by Messrs. Blackmore, Paul, and Mackay.

The President: We will proceed to the next paper: "Test of Radiators with Superheated Steam," by Prof. R. C. Carpenter.

Professor Carpenter read his paper, which was discussed by Messrs. Hibbard, Paul, and Blackmore.

The President: We have some topics for discussion. The first topic is one contained in a communication from Mr. Maguire. The secretary will please read that communication.

The secretary then read an extract from the communication from Mr. Maguire, as follows:

"What do you think of the system of calling for specifications and estimates, without making any honest attempt to pay any remuneration to the engineer who answers the call?"

The President: We have had this subject before us several times, but it has been raised again, and we should be very glad, indeed, to hear from any member on it. It is a question of furnishing plans and specification to architects for nothing.

The topic was discussed by Messrs. Wilkes and Mackay.

The President: The next topic is the advisability of the adoption of the metric system.

After a brief discussion the meeting adjourned until 8 o'clock in the evening.

SECOND SESSION.

The meeting was called to order at 8 P.M., Friday, July 12, 1901.

The President: The business this evening is to listen to a paper by Mr. Reed: a description of the heating system of the St. Louis schools.

Mr. Reed then read his paper, using lantern views in illustrating the different points. It was discussed by several members.

After the discussion the Society adjourned until the next day at 9.30 A.M

THIRD SESSION.

The meeting was called to order at 9.30 A.M., July 13, 1901.

The President: The society will please come to order.

The first business on the programme this morning is the reading of a paper by Mr. Mackay: "Volume of Water in a Hot-Water Heating Apparatus."

Mr. Mackay then read his paper, which was discussed by Professor Carpenter, Mr. Reed, and Mr. Folsom.

The President: If there is no further discussion we will pass the paper and go to the next business, which is the discussion of a topic. The topic is: "What is the life of metal air ducts, and under what conditions may they be dispensed with?"

I will ask Mr. Reed to open this discussion by speaking of the metal air ducts. He uses a great many of them.

After the discussion of this topic the next topic was taken up and discussed, viz.: "What is your experience as to the life of wrought-iron or steel nipples used in connection with cast-iron radiators?"

This was followed by the topic: "What has been your experience in the use of anemometers?"

The Secretary: Mr. President, we have invitations extended by three of our members: Mr. T. J. Waters invites the society to visit the Robert A. Waller High School building in this city; Mr. Samuel G. Neiler to visit the Mongomery Ward building, and Mr. C. M. Wilkes invites the members to visit the Merchants Loan & Trust building in this city.

At a meeting of the Board of Governors this morning, the

question of the advisability of the members visiting these different buildings in a body was considered, and it was found that a number of those present had different engagements that would prevent the possibility of their accepting any or either of them, and it was deemed advisable to decline as a body, while any of the individual members can make arrangements to visit any of those buildings should they wish to do so. At the same time it seems that the kindness of these members and their efforts to please the visiting members should be considered in some way, and I would move you, Mr. President, that a vote of thanks be extended to Messrs. T. J. Waters, C. M. Wilkes, and Samuel D. Neiler, for their kindness in inviting the society to visit these different buildings.

The President: Is there a second to the motion.

Professor Carpenter: I second the motion.

The President: The motion is carried, and the secretary will write a letter to these gentlemen.

The Secretary: I move you, Mr. President, that we now adjourn.

Motion was seconded, carried, and the society adjourned.

FOURTH SEMI-ANNUAL MEETING.

The following members and guests were registered as being present during the meeting.

MEMBERS.

J. J. Blackmore.	J. D. Hibbard.	W. M. Mackay.
R. C. Carpenter.	J. H. Kinealy.	A. G. Paul.
Jas. H. Davis.	August Kehm.	A. D. Reed.
C. G. Folsom.	A. T. Kellogg.	T. J. Waters.
A. Harvey.	C. V. Kellogg.	C. M. Wilkes.

GUESTS.

Geo. W. Cope.	J. F. Leslie.	Thos. K. Peters.
G. E. Downe.	W. H. Macon.	L. E. Riddle.
L. H. Drury.	P. J. Markman.	H. L. Sherriff.
H. W. Ellis.	Jas. McAlear.	Oliver Schlemmer, Jr.
I. A. Hardy.	D. E. McCabe.	E. E. R. Tratman.
J. F. Harmon.	Jas. J. McDonald.	C. B. Thompson.
P. S. Hudson.	S. F. McDonald.	J. L. Welshans.
Chas. M. Howe.	D. F. Morgan.	C. L. Williams.
H. Kauffman.	A. H. Park.	B. E. VanAuken.

LXXXVI.

EFFECT OF CIRCULATION ON THE CAPACITY OF FIRE-BOX HEATING SURFACE.

BY R. C. CARPENTER.

(Member of the Society.)

The following paper gives the results of a few experiments, which were made during the early part of the year 1900, by Mr. E. G. Chandler and H. H. Clark, under the writer's supervision, to determine the effect of velocity of circulation of water on the capacity of fire-box heating surface, and also to determine the relative efficiency of different portions of the surface. The experiment as planned consisted in an investigation covering the efficiency of the direct heating surface in the fire-box, and also of the secondary surface not acted on by the radiant heat of the fire; but at this date that portion relating to the fire-box heating surface only, has been completed. The results are in consequence applicable to only a few cases. They are, however, presented to the society principally for the purpose of inciting discussion, and obtaining suggestions for the continuation of the work as planned.

For the purpose of the investigation it was decided necessary to construct a fire-box of such elementary form as would permit an accurate measurement of the heat absorbed by each part. With this end in view a fire-box was designed which could be constructed by combination of different rectangular elements, so arranged as to form the sides and top of heater immediately adjacent to a grate. The dimensions of one of these elements are shown in Fig. 1. It is seen to consist of a hollow rectangular casting, 23½ x 6½ x 2½ inches outside dimensions. Each element was constructed with several bosses arranged conveniently for pipe connections as needed.

A vertical section through the furnace as erected is shown in Fig. 2. This shows a grate containing 4 square feet, which was supported on brick work underneath the heating surface.

The heating surface was arranged so as to surround the fire, being built up by placing three elements as shown in Fig. 1, on each side above the grate, two elements in front and two back, the whole structure being then bricked over, with brick

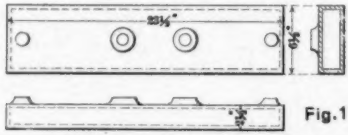
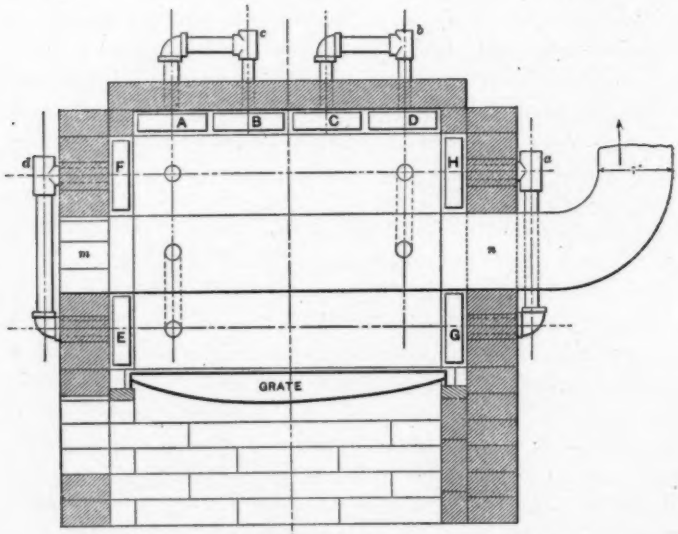


Fig. 1

VIEWS SHOWING FORM OF CASTING

laid about ½-inch from the iron castings. A fire-door, *m*, was made in front by leaving an opening in the brick work. A smoke-flue was made through the back wall at *n* by leaving an opening in the brick work to which a stove pipe leading to a

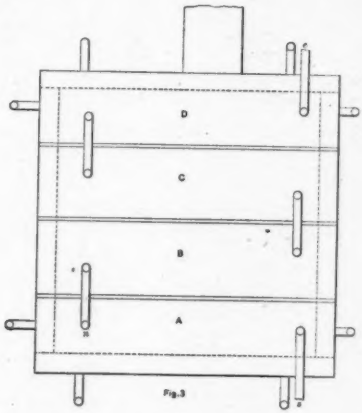


SECTION OF FURNACE

Fig. 2

chimney was attached. With this arrangement no heating surface existed on the sides of the furnace immediately adjacent to the fire-door and smoke-pipe. The elements constituting the fire-box were arranged for water circulation in such a

manner that water could be passed in series through all the elements of the heater, or, if desired, a measured amount could be passed through each element. Arrangements were made for taking the temperature before and after passing through each element, or before and after passing through the entire heater, as needed. During the tests, water was used at such a rate as to maintain, except in a few cases, such a temperature as to preclude the possibility of any steam forming. A pyrometer was placed in the flue back of the fire, for the purpose of measuring the temperature of the flue, and to enable the observers to maintain uniform temperature conditions of the discharge gases. During the tests that were made the rate of firing was main-



tained uniform, as nearly as possible, its uniformity being determined by the readings of the pyrometer.

The general results of the tests are given in the following tables of data, and are also shown graphically in the diagrams. Thus in the diagram Fig. 4, the velocity of circulation in feet per minute is represented as corresponding to horizontal distance, and the B. T. U. per sq. ft. of heating surface absorbed per minute is represented as corresponding to vertical distance. It is noticed from this diagram that with all other conditions constant the rate of heat transmission, increases rapidly with increase in the velocity of water circulation. This teaches an important practical lesson; namely, that circulation of water has an important influence on the practical results to be ob-

tained from heating surface in a boiler. It shows that the more rapid the circulation; the higher the efficiency of the heating surface should teach the designer of boilers to make his con-

DATA SHEET.

Run No.	Time.	Temperature. Entering.	Leaving.	Flue.	Water. Total Lbs.
1	12:50	61	93	450	
	1:00	61	98	482	
	1:10	61	100	458	
	1:20	61	101	460	1150
	Average.....	61	98	462	
2	1.25	61	148	465	
	1:35	62	148	450	
	1:45	62	138	435	
	1:55	62	135	410	600
	Average.....	62	142	440	
3	2:13	62	185	456	
	2:20	62	190	456	
	2:30	62	186	456	
	2:40	62	185	458	400
	Average.....	62	186.5	456	

Run No.	Time.	Temperature. Entering.	Leaving.	Flue.	Cond. Steam. Lbs.	Cold Water. Lbs.
4	10:45	63		458		
	10:55	63		450		
	11:05	63		490		
	11:20	63	162	508	150	250 at 59°
	Average.....	63		474		
5	12:00	65		532		
	12:10	66		544		
	12:20	68		500		342 at 59°
	12:34	69	168	502	58	
	Average.. ...	67		519		

RESULTS.

No. of Run.	B. T. U. per Min.	Lbs. Circulated per Min.	B. T. U. per Sq. Ft. per Min.	Vel. in Feet per Min. of Flow.
1	1,210	1.9	86.5	.031
2	1,150	2.2	82.2	.035
3	1,390	11.7	99.5	.187
4	1,450	20.	103.5	.32
5	1,570	44.2	112.	.706

structions in such a manner as to induce the highest possible velocity of water in the heater.

The special form of fire-box employed may not teach us much in a general way as to the relative efficiency of different

portions of the fire-box surface; but in the special fire-box under discussion, the results were as given in the following tables. The greatest amount of heat was absorbed by those sections which were in closest proximity to and immediately surrounding the fire.

DATA OF EXPERIMENTS OF HEAT ABSORBED BY DIFFERENT SECTIONS.

Time.	Left Side.				Back Sections.			Top Sections.					Right Side.				Front.			Flue Temp.
	Ent.	1–2.	2–3.	Lv.	Ent.	G–H.	Lv.	En'.	A–B	B–C.	C D.	Lv.	Ent.	1–2.	2–3.	Lv.	Ent.	E–F. 1–2.	Lv.	
2.30	67	100	125	153	66	116	134	69.5	80	90	106	114	67	102	132	150	69	117	174	440
.40	65	112	130	148	67	132	155	69.5	80	92	110	116	67	112	140	160	69	103	130	440
.50	67	118	143	155	67	143	165	70	82	95	114	122	67	117	148	170	69	102	130	440
3.00	66.5	122	140	155	67	90	98	69	84	100	122	132	67	82	92	105	69	105	136	490
.10	67	94	112	125	67.5	100	110	70	86	105	130	140	66.5	94	106	112	69	110	148	460
.20	66	98	112	125	67	98	110	69	85	110	136	150	66	96	112	125	69	100	130	420
Av...	66	109	127	143	67	113	129	69.5	83	99	120	129	68	101	122	137	69	106	141	448
Total Water Pounds		245				295				685				255				192		
Water per Min.		4.08				4.92				11.4				4.25				3.2		

Sections on each side are numbered from bottom up; those on top are lettered as in Fig. 2.

RESULTS.

	Back.		Front.		Sides.			Top.			
Number of casting... ...	1	2	1	2	1	2	3	A	B	C	D
B. T. U. per minute.....	198	65.1	98	93	172.5	90.2	74.5	68	105	141.5	63.4
B. T. U. per lb. water per minute..... ...	39.3	13.25	30.6	29.1	41.5	21.6	17.9	5.96	9.2	12.4	5.56

A series of tests was also made in order to determine the effect on capacity and efficiency due to supplying water at different temperatures. The temperature of the feed water was varied from 60 to 135 degrees. The results of this series of tests were not conclusive; the heat absorbed per degree difference of temperature per pound of water supplied, being

in most cases substantially uniform regardless of the temperature of the feed. This is clearly shown by the following table:

RATE OF FLOW IN POUNDS PER MINUTE.

No. of Run.	Front.	Left Side.	Top.	Right Side.	Back.	Total.
1	3.86	6.82	76	4.93	5.2	28.41
2	5.5	10.2	13.4	6.3	13.3	48.7
3	7.5	6.1	12.6	4.9	6.4	37.6
4	7.5	10.3	12.9	6.4	10.7	47.8
5	5.6	13.1	13.1	4.3	8.1	44.3

GAIN IN TEMPERATURE DEGREES FAHR.

No of Run.	Front.	Left Side.	Top.	Right Side.	Back.	Feed Entering.
1	53	73	38	49.5	45.3	63
2	33.3	42	29	42.5	22	86
3	28.2	62.3	30.3	4.5	27.3	102
4	21	44	31.8	39 3	4.4	122
5	27	28.8	30.5	33.5	19.5	133

GAIN IN B. T. U. PER MINUTE.

No. of Run.	Front.	Left.	Top.	Right.	Back.
1	204	500	288	244	235
2	183	428	388	268	292
3	213	380	383	222	175
4	158	453	412	251	471
5	151	378	400	146.5	155.5

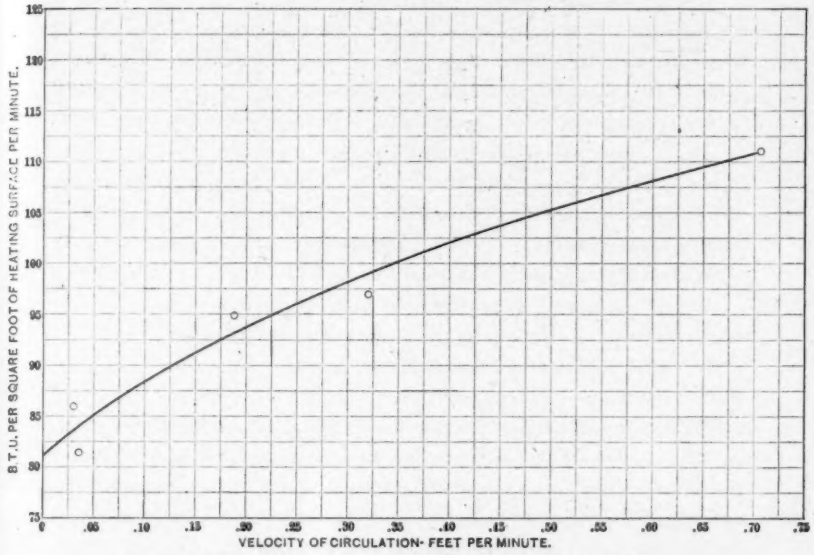
TOTAL GAIN IN B. T. U. PER MINUTE.

No of run.....	1	2	3	4	5
B. T. U.....	1,471	1,559	1,373	1,745	1,234
B. T. U. per No. per minute...	52	32	36.6	36.6	27.8

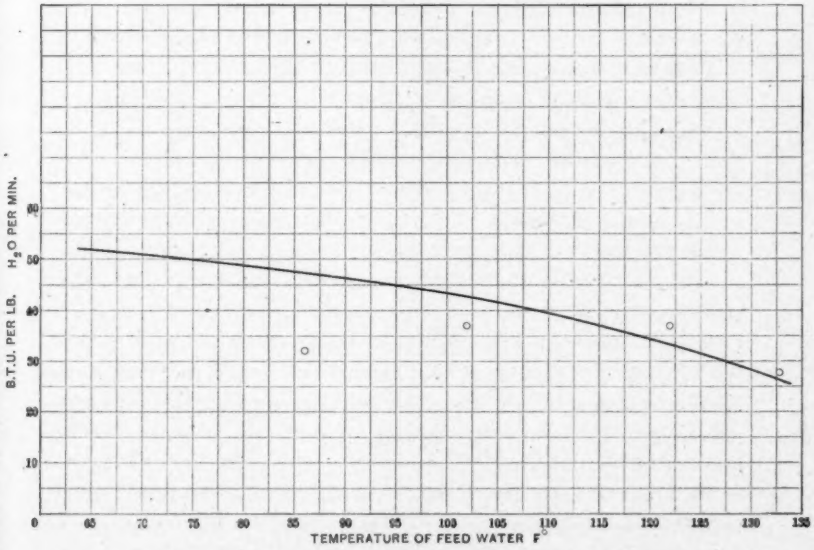
DISCUSSION.

Mr. Blackmore: The results would depend on what kind of fuel you used during the test. What kind of fuel did you use?

Professor Carpenter: Hard coal, chestnut coal.



Effect of Circulation on the Capacity of Firebox Heating Surface, Fig. 4.



Effect of Circulation on the Capacity of Firebox Heating Surface, Fig. 5.

Mr. Blackmore: And had you a perfect fire during this time?

Professor Carpenter: Oh, yes, we had an excellent fire.

Mr. Blackmore: What I had reference to is this, that in order to get perfect combustion I thought that it would require considerable time to get the fire started.

Professor Carpenter: Oh, yes, it did. The fire has to be started several hours before the experiment could be made.

Mr. Paul: Did the coal lay against the bottom section?

Professor Carpenter: Yes.

Mr. Blackmore: How large is the fire-box?

Professor Carpenter: Four square feet, two by two.

Mr. Blackmore: Professor, how did you determine the velocity of the water?

Professor Carpenter: That was done in this way: We measured the amount of water that was pumped through the sections; the area of cross-section in square feet on the inside of each one of these sections was known, and the velocity computed through the sections, not the velocity in the pipe. We computed the velocity by the number of cubic feet that went through in a given time, through a given area.

Mr. Blackmore: Don't you think, if the smoke-pipe had been taken out of the top that it would have affected it differently?

Professor Carpenter: It may be. This test is put before the meeting entirely for the purpose of obtaining suggestions. The arrangement employed was the form here shown.

Mr. Blackmore: Of course, the conditions you have there are entirely different from what they would be in probably nine-tenths of the boilers in use; that is, the gases are carried upward.

Professor Carpenter: The gases were carried at a very high temperature right into the chimney.

Mr. Blackmore: Yes, and carried off practically just as they are formed. Whereas, in the ordinary case the gases are carried up through the ordinary flue or chamber; and, my question was as to whether the smoke-pipe was in the best position to make a test.

Professor Carpenter: This structure was intended to represent a fire-box section of the boiler, but we intend to go on further with the tests.

Mr. Blackmore: The question in my mind is whether that smoke-pipe was in the best position to make a test, and whether that fire-box as you have it there represents the conditions of a fire-box in a boiler. Of course, as your experiments develop that can be determined. Were you able to get the value of relative different parts of the surface?

Professor Carpenter: That is the point that I tried to make clear, that the difference was not very marked. We got the highest evaporation from these sections which are nearest the fire, about the same back and front, and the sections which were furthest from the fire gave us the least.

Mr. Blackmore: Now, did you determine, Professor, whether these sections that were in the fire were as efficient after they had been in the fire several hours, as soon as a certain amount of ashes were accumulated on them? I want to ascertain whether you noticed that that made any marked difference.

Professor Carpenter: We did not try to determine that at all, and, in fact, the immediate investigation would hardly decide that question, because it was to determine the relative proportion of the surface, and the effect of circulation through it, but the fire was clean all the time and in good condition.

Mr. Blackmore: I mention that fact for the reason that it is important, if it is a case of comparative results. We have to admit the fact that the ordinary condition of a boiler such as you have there would be to become dirty around the edges, which would very materially change the relative position or relative efficiency of the different parts. Did you test each section separately?

Professor Carpenter: Yes.

Mr. Blackmore: Was the difference as much as ten per cent.? Of course, you gave it there, but I didn't catch it.

Professor Carpenter: The difference was rather irregular in the different sections, as the figures show. Taking the sections running from front to back, they give on an average 83, 99, 120 degrees; now, take the sides, on the same scale, the back sections give 67, 113—which you see are not very greatly different; the left side, 109-127; the right side, 101, 122, and the front, 106, 141 degrees. In the back section: we find the lower one 93 degrees; the upper one was 65 degrees; in the front section, the lower one, 98 degrees; and upper one, 93 degrees; in

the top front section, 105 degrees; third section, 141 degrees; back section, 63 degrees. These are average measurements during the period under test.

Mr. Blackmore: That is a very much greater difference than I would expect to see.

Mr. Hibbard: The top, as I understand, represents the crown sheet, getting the heat directly, from direct radiation, while the other was getting it by conduction?

Mr. Blackmore: Of course, as your experiments develop, I don't know but what you will have to make greater and greater changes. My questions were asked merely to provoke discussion, and see if we could get improvement on some of the propositions involved in that question. It is important because owners, manufacturers, and engineers consider the sheet is the best surface, because it has the advantage of the heat of the gases going through as well as the radiating heat of the fire, and your experiments go to show differently. Now, whether you had the smoke-pipe changed so the smoke is taken off at the top, whether that would be an advantage is a matter to be determined.

Professor Carpenter: We will be able to change that very nicely. If there is any suggestion, we would be glad to have them, because we are in the infancy of the experiment and future methods are open for discussion.

Mr. Hibbard: I am very much interested in the subject. When you are making that test will you put in a fire-box of brick; because it is impossible to get or sustain a perfect combustion with water surrounding the fire.

Professor Carpenter: We can do that; we can do that nicely. We can also change the position of the smoke-stack.

Mr. Hibbard: Yes, you could do that and then have a bridge wall or deflecting wall.

Mr. Blackmore: Professor Carpenter, there is one more question I would like to ask. Did you try at all to see whether any difference was made when you let air in at the surface of the fire or not?

Professor Carpenter: No. These tests were made with a perfectly uniform fire, and we did not go into the question of the effect of different methods of firing.

Mr. Blackmore: By that experiment, as far as it went, it cer-

tainly showed comparative results. It is somewhat of a surprise, but it is very satisfactory.

Professor Carpenter: I felt like apologizing for putting an unfinished experiment before the society, but I wanted to get an expression from the members on the subject.

The President: Mr. Mackay, you are interested in hot water heating, haven't you something to say about this discussion?

Mr. Mackay: I have been quite interested, and it is just as Mr. Blackmore says, I am surprised at some of the results, because the results that I have obtained have been a little different, although the location of the smoke-stack or smoke-flue may have had something to do with it; and it seems that it would be an advantage to put a plate there that would induce the hot gases in combustion to reach the upper surface before they drop down, they have to drop some six inches, and it seems to me that was carrying off part of the combustion; that is as soon as the gases from the fire become ignited, they are carried off into the chimney and are not allowed to come in contact with the upper surface. It seems to me that that would be something that ought to be added at the next experiment, and perhaps increase the efficiency of the upper surface.

But, of course, in general practice we find that after the first fire, the sides of the fire-box become coated with ashes and other foreign substances which interfere with the efficiency of the lower sections. Generally, while we depend upon the surfaces below the one in contact with the coal for certain results, when the fire is cooled above, by fresh coal being put on it, we look for better results from the upper surface and particularly the horizontal surfaces, than we do from the lower vertical surfaces.

There may be a reason for the results in the arrangement—in the way that the gases are taken off. We would usually allow the gases in combustion to pass over the upper section before we take them off, of course, coming in contact with the surface above; that, I think, would reverse the results obtained in this test; I think it would increase the efficiency of the upper surface at the expense, perhaps, of the lower surfaces.

Professor Carpenter: We will try that.

Mr. Hibbard: That is the circulation in the top of the fire-box depended upon the quantity of fire and the size of the opening for the gases to go out.

Now, did you take any observations as to whether the whole work done by the upper sections was not done by radiant heat, not by circulation of gases by the surface? Changing, as the others have suggested, the position of the smoke-flue would make the circulation of gases by the upper sections; whereas, in this case, it seems to me the whole question was the size of the smoke-flue being sufficient to take away the gases as soon as they arose, so that you get no effect except by the radiant heat. Now, did you shut down the damper at all to force the gases to go to the top?

Professor Carpenter: No. The position of the smoke-flue may effect that, although you must understand that this distance here is only six inches, vertically, in this corner. The pipe, six inches in diameter, was attached to a one hundred foot chimney; we had a draught on it of about ¾ of an inch, pretty strong, I think.

Mr. Morgan: You say that the surfaces close to the fire are those that absorb the heat. As a matter of fact the water that passed through those surfaces was not returned to them, but passed off, was it not? The water that went in from that surface went away; it did not come back again to the surface, did it?

Professor Carpenter: No, in no case did it do that.

Mr. Hibbard: My judgment of that would be that the upper sections were heated entirely by radiant heat, not by circulation. A drop in front of the smoke-pipe would displace the air at the top and pass that up the smoke-stack, then you would get the true heat of the fire.

Professor Carpenter: I think that may be true to a certain extent, but I think there was a good deal of circulation in the top. We didn't find as we increased the circulation an increased capacity of the heating surfaces—there was an indication that we had quite a strong circulation up through the top, but I have no doubt there will be a good deal of difference with a stronger circulation.

Mr. Morgan: The flame of the gas and the heat of the gas, that gives you the results. As I understand, you can get about 2,600 degrees from perfect combustion with hard coal. To get the best results you would have to get proper combustion; there must be perfect combustion before you can get the gases thoroughly ignited.

Professor Carpenter: I think we can apply the results so far as they had to do with the circulation of water as a general proposition, but so far as efficiency of the different parts of the fire-box is concerned, I am inclined to think that no general application can be made.

Mr. Morgan: This was simply not a test for combustion, just a test for effect of circulation of water?

Professor Carpenter: That is what it was intended to be.

Mr. Morgan: I think a fire-box might be tested as to relative value of the surface, which would be of great benefit to everybody concerned.

Professor Carpenter: We are planning to build above the fire-box secondary surfaces, and carry the heat over them before discharging into the chimney, but we have that work to do yet. I think, perhaps, when that is done it will result in a fair distribution of heat in the portion that we have already built.

The Secretary: Mr. Chairman, I would like to suggest to Professor Carpenter in connection with that test: that it could be made nearer a test of a commercial boiler by setting the blocks vertically, and placing them apart so that gases of combustion would go between them to the space above. I believe you will then find that the upper surfaces will be doing better work.

Professor Carpenter: It might be a good thing to try them.

The President: It seems to me, gentlemen, that our discussion has been confined almost entirely to one part of this paper, that is the efficiency of the different parts of the fire-box. To me the most interesting of the paper is that which refers to the difference in transmission of heat with the different velocities of water. That, I believe, has not been touched upon in this discussion. It would indicate that a boiler of small capacity would give better results than a boiler of larger capacity with the same heat surface. Isn't that the conclusion to be drawn, Professor Carpenter? That is, the more rapid the circulation the better the result?

Professor Carpenter: Yes, sir.

The President: I would like Mr. Blackmore to tell us how that agrees with his experience.

Mr. Blackmore: That is entirely in accordance with the experience of myself and most boiler men; we notice, particu-

larly in the case where we use a steam boiler for hot water and *vice versa*, there are certain considerations—if, for instance, we construct a boiler with an idea to its efficiency as a water heater, simply to get the most out of it as a hot water heater, that is, a circulation with a comparatively low temperature, we can get very high efficiency per square foot heating surface, and much higher efficiency than we can when we attempt to use the same boiler for steam, and the only thing we can attribute that fact to is that the lowering of the temperature of the water, which would be the cause of the active circulation; and there is not only a greater difference between the fire and the absorbing surface, but it enhances the conducting power.

Professor Carpenter: We have a heater which was sent for testing, and by changing the rate of circulating water through it, we could increase its capacity some four or five times, with the same amount of surface.

Mr. Blackmore: Was that not due to the fact that by increasing the circulation you could bring all parts of the heater into use?

Professor Carpenter: This is doubtless in part correct; the rapid circulation of the water causes particles of the water to strike against the metallic wall of the tubes, and absorb all the heat which passes through the metallic walls just as fast as it came, whereas, in the case of slow circulation there was short circuiting and inefficiency of the heater.

LXXXVII.

HOT AIR FURNACE HEATING.

BY C. G. FOLSOM.

(Member of the Society.)

The subject which I present to-day is, "Hot Air Furnace Heating." The building shown in the drawings is exposed on all sides—no protection whatever—a frame structure thoroughly built on a stone foundation (what we term, in this country, field stone), cement-mortar, and is a two-story residence with an attic. The first story is stone veneered six inches thick.

The buildings here of this description are mostly all isolated, and not constructed on the same plan and with the same idea that city buildings are constructed, where the ground that they are built on is worth considerably more than it is in our city (South Bend, Ind.).

The house is well arranged, as a residence, and very convenient. It is work of Freyermuth & Maurer, architects, of our city. The structure, as it now stands, costs about $6,000, and I will state that I contracted the heating of this building at a disadvantage, for the frame was up and enclosed, chimney was built, and it was left me to arrange as best I could. The party wanted the work the best that could be had under the circumstances and was willing to pay for it.

The furnace used was a tubular furnace, with 26-inch fire pot, the grate being of the open labor-saving pattern. There are fourteen pipes from this furnace, which consume nearly all available space on the top of the furnace. The pipes are fully as large, or larger, than those often used when doing cheaper work. The stacks are larger than are usually placed in a building in this part of the country—sizes 4 x 12 inches, which is the space that is between the studding. There are 30,000 cubic feet to heat. The manufacturer's estimate is 30,000 to 50,000 cubic feet for this particular heater.

There is a lining of tin all around inside of what is termed

the casing, which is of galvanized sheets; there are asbestos sheets pasted on the inside of this casing.

The piping is of what is termed bright charcoal tin, IX., and the points are double seamed. The wall stacks are of bright tin and are double, except two of them which are covered with three thicknesses of asbestos paper pasted on. At the base of each stack there is a boot of extra size, also of bright tin. The longest round pipe from furnace is 26 ft. 8 in. long, and 9 in. in diameter. This connects with a stack to the bathroom on second floor. This stack has an outlet or register 5 ft. from floor,

FIG. 1.—VIEW OF HOUSE.

as there was no place in the floor for the register. The shortest pipe is about 8 ft. long and 10 in. in diameter. The round hot-air pipes rise about 1 in. for every 10 ft. of length. The basement is 7 ft. 6 in. high, and you readily see by this, that I did not have elevation enough for the pipe. Where I can have it, I prefer 2 ft. rise in 10 ft. length of pipe.

The furnace is over a pit 24 inches deep, and the air duct is formed by a 4-inch brick wall on two sides of a trench, that is 24 inches deep, and wide enough to have a capacity of 720 square inches.

Now, the area of one 12-inch pipe is 113 square inches, and in three of them there are 339 square inches.

The area of one 10-inch pipe is 78 inches, and in three of them there are 234 cubic inches.

The area of one 9-inch pipe is 63 inches, and in eight of them there are 504 square inches, making a total of 1,077 square inches.

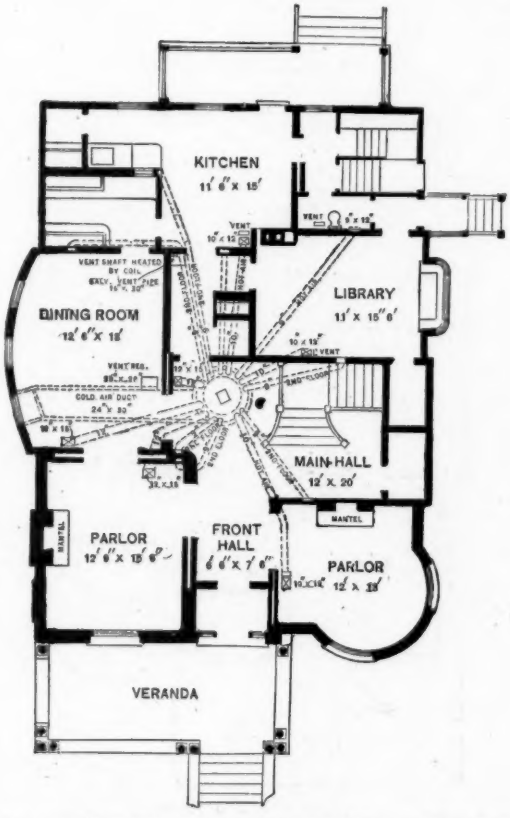


FIG. 2.—FIRST FLOOR PLAN, SHOWING PIPES IN BASEMENT.

There is thus nearly two-thirds as much cold-air inlet as the combined area of the fourteen pipes that carry the hot air from the furnace to the several rooms in the house.

In the dining-room is a register face, 28 x 28 ins., that takes the return air from hall, two parlors and dining-room. The outside air that is used is taken at a window in the basement up

near the joist, and is conducted down to a duct under ground. This return air duct is attached to the downward duct from the window so that by turning a damper, which has a handle on the outside of the duct, the air can be used either from the outside of house or an inside circulation can be used.

There are return air ducts, made of bright tin, from every

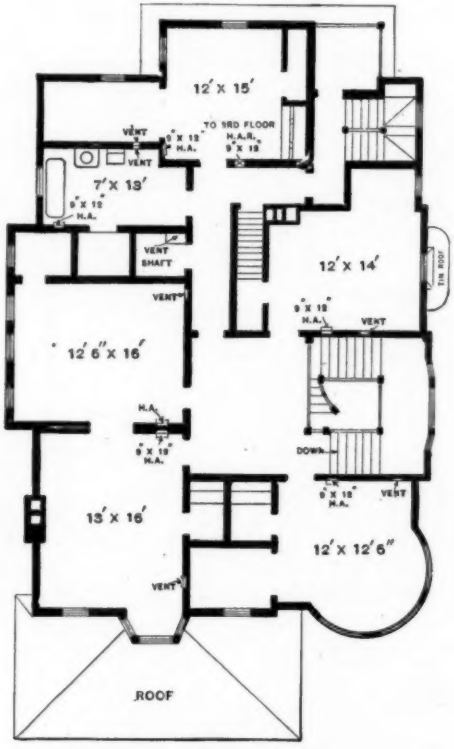


FIG. 3.—SECOND FLOOR.

room in the house, that connect with this inside box, for the circulation of the partly heated air. These bright tin pipes are three-fourths the capacity of the hot-air pipes from the furnace to these reception rooms.

By the side of the door in the furnace, that opens to receive the coal, there are two 1-in. holes to place water pipes in. These pipes extend into the furnace over the fire; but this pipe

is for the purpose of heating a galvanized iron stack that extends from the basement up into the attic, and is carried over into a large chimney flue. This stack is for the purpose of ventilating the two closets (one on second floor and one on first floor).

There is a tank in the attic which is filled with rain water, and is connected with this hot-water coil in a galvanized iron stack to create a draught of foul air from the closets.

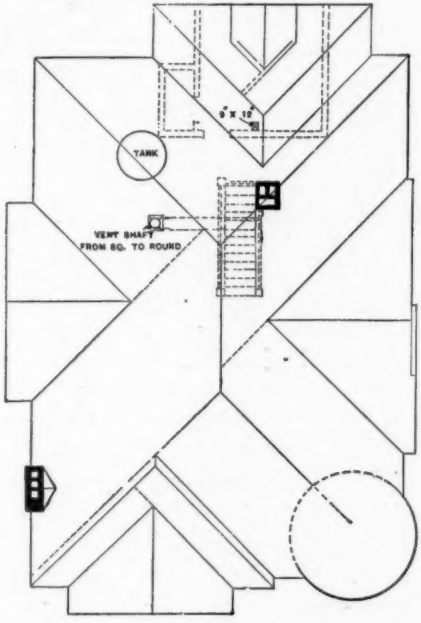


FIG. 4.—ATTIC.

I made only five examinations of the temperature of the rooms of the house. This was in January, February, and March. The average was 60 degrees. All but one were made in the morning, and that one was at 4 o'clock P.M All the fuel was hard coal and there were not ten tons used from October 29, 1900, to May 1, 1901. The family were satisfied with the temperature of the house. I was there when the thermometer registered 8 degrees below zero. This was the only time that I saw the fire at a white heat.

I have no way of testing the velocity of air at the register, except an anemometer, and I could not get much satisfaction, for my experience is limited in the use of the instrument.

In drawing the air out of the galvanized stack, I was surprised to find how these two small rooms were so easily heated; in the coldest weather they were the warmest. At least they were always warm.

In this house there is a small family—man and wife and two children—and the leakage into the house of fresh air was considerable. The glass surface is enormous. All of the windows are large—at least one-eighth of the entire side walls.

In ordinary practice we do not take glass surface into consideration for we try to install a furnace large enough to overcome all that is required.

DISCUSSION.

The President: I should like to ask Mr. Folsom, isn't it rather unusual to have a rise of only one inch to the foot for a hot-air pipe?

Mr. Folsom: It is, yes, sir. It is very unusual, but we had to take the house just as it was; we had to do the best we could with it under those circumstances.

The President: Can anybody give us any information upon the use of the anemometer? Mr. Reed of St. Louis is here, and I think he has used the anemometer. What has been your experience?

Mr. Reed: Very much the same as Mr. Folsom's.

Mr. Blackmore: How much coal did you burn in the house?

Mr. Folsom: I was very particular to find that out; a little less than ten tons of coal.

Mr. Blackmore: Did they heat all the premises?

Mr. Folsom: Heated every room in the building. The house is all open.

Mr. Paul: What are the outside dimensions of the house?

Mr. Folsom: From outside to outside it is 36 by 56, or 58 ft. Those are the outside dimensions of it. It is a two-story house with basement and attic, a large attic, and one of these rooms that was heated was in the attic.

Mr. Hibbard: Was the basement heated?

Mr. Folsom: No, sir; it was heated by the radiation from the pipe, that is all.

Mr. Mackay: Did you attempt to heat the attic with the same diameter of pipe?

Mr. Folsom: There is just one small room in the attic, one room 10 x 13 ft. We used a 4 x 12-in. pipe and a 10 x 10-in. register.

LXXXVIII.

TESTS OF RADIATORS WITH SUPERHEATED STEAM.

BY R. C. CARPENTER.

(Member of the Society.)

In making a series of radiator tests during the spring of 1901, superheated steam was inadvertently used in several cases. To my surprise the capacity for heat transmission of the radiator was thereby reduced. I did not have sufficient time to investigate the phenomena exhaustively, but the data which were taken seemed to be of such general interest, that I have concluded to present the results of the test to the society, for discussion.

The radiators tested are named respectively, No. 1 and No. 2; No. 1 was 18 ins. in height and contained 10 sections, each 11 ins. wide, constructed so as to have very little air space between the sections, the least distance between sections being ½ in. No. 2 was 38 ins. in height and contained 10 sections, each 9 ins. wide; and spaced so as to give abundant room for air currents around the sections. The least distance between sections was ¾ in. The radiators were both tested with steam, which was taken through a single inlet; No. 1 being of the hot-water type with top connection as well as bottom connection of the sections, whereas No. 2 was of the steam-heating type with no top connection of the sections. The dimensions are given in the accompanying table.

DIMENSIONS OF RADIATORS.

	No. 1.	No. 2.
Total height, inches	18	38
Height of leg, inches	2	3
Least distance between sections, inches	½	¾
Total length, inches	24½	24
Thickness of radiator, inches	11	9
Type	Hot Water.	Steam.
Number of inlets	1	1
Measured surface, square feet	38.6	49.1

The radiators were arranged for testing on a platform having an elevation about 2 feet above the floor, and sufficient to insert vessels underneath the radiators to obtain the water of condensation. Steam for the test was obtained from a high pressure main which passed through a steam separator to remove any free water, thence through a reducing valve set to maintain the desired pressure, thence to a receiver located between the two radiators. From the receiver a pipe was led to each inlet of the raidiator. The water of condensation was taken off at the inlet end, and permitted to drip into a receiver provided with a water glass, arranged in such a manner that the water in the receiver could be held at a uniform level, which was about one foot below the bottom of the radiator. The water of condensation was cooled before being weighed. Temperatures were taken of the outside air and at several places in the air of the compartment in which the test was conducted. Temperatures were also taken of condensed steam and of the surface of the radiator on two sides. In taking the temperature of the surface of the radiator, the bulb of a thermometer was fastened against the metallic wall of the radiator, and protected from external radiation by hair felt. This test does not give the temperature of the radiator, because of the cooling of the thermometer bulb, but it gave useful information as to the distribution of heat in the radiator. The two radiators tested were kept at a distance of about six feet, and the effects of radiation from one to the other were counteracted by a partition midway between the two. The radiators were shielded from any currents of air; and the room was kept, as nearly as the outside conditions would permit, at a temperature of 70 degrees Fahr.

The writer has observed in previous tests of radiators that when testing a high and a low radiator, the low radiator would always show greater heat transmission for the same surface exposed. In these tests we have an apparent exception to this rule, as it will be noted that the higher radiator gave a higher rate of heat transmission per square foot of surface than the lower. An examination, however, of the dimensions of the radiators will show that the air space surrounding the sections in the low radiator was very much less than in the high. While I have not an accurate measurement of air space, it is probable

that the air space per unit of surface in the high was about four times that in the low radiator. The test is interesting, as showing, that by properly proportioning the air spaces between the sections, the heat transmitted per unit of surface in high or low radiators may be equalized. This also shows that the air space doubtless plays an important office in carrying away the heat from the radiators.

Expressing the final results in terms of the number of heat units transmitted per hour per square foot per degree, we have the following results, as applicable to the case where there was either no superheating of the steam or only a very slight amount:

Steam Pressure. Pounds.	Superheat. Degrees.	B.T.U. per Square Feet per Hour per Degree.	
		Radiator No. 1.	Radiator No. 2.
2	0	1.48	1.83
2	0.13	1.50	1.92
10	0.30	1.50	1.91
30	1.10	1.83	1.97

These results indicate a substantial uniformity in heat transmission per degree difference of temperature from 2 pounds to 10 pounds. Test No. 1 as 30 pounds pressure, shows as would be expected, increased heat transmission, but is otherwise not considered in this discussion.

The process of reducing the pressure wire-drew the steam, thus liberating a considerable amount of heat energy which expended itself in superheating the steam. The effect of liberating this heat energy without work was to superheat the steam and this, contrary to our expectations, was to reduce the amount of heat transmitted. Thus with radiator No. 1, with no superheat, the heat transmission per hour per square foot of surface per degree of difference of temperature, which we will term hereafter the heat transmission, was 1.48 B. T. U.; with about 36 degrees superheat, this was reduced to 1.16 B. T. U. With radiator No. 2, there was a corresponding reduction from 1.83 to 1.41 B. T. U.

With 5 pounds of steam pressure and when steam was superheated 13.1 degrees, the heat transmission was 1.41 for the low

radiator, and 1.74 B. T. U. for the high. When the degree of superheat was increased to 24.1 degrees, the heat transmission of the low radiator fell to 1.23 B. T. U., and that of the high to 1.45 B. T. U.

With 10 pounds of steam pressure the heat transmission for $\frac{3}{10}$ degree of superheat was for the low radiator 1.5 B. T. U., and for the high radiator 1.9 B. T. U. When the steam was superheated to 26.7 degrees, the heat transmission fell to 1.24 for the low radiator, and 1.62 for the high radiator. Several check runs were made, the results of which show a variation of less than 2 per cent., except in the case of run 5, where the variation was about 5 per cent. This run is given uncorrected, although the results are probably 2 or 3 per cent. high, because of some condition which could not be determined. Possibly, the radiator may have been in a slight draught of air, although measures were taken to prevent such an occurrence if possible.

The conclusions to be drawn from the tests made with superheated steam would indicate that it is a poor medium to employ for heating purposes, the reason doubtless being due to the fact that superheated steam is much more nearly like a perfect gas in its nature than a saturated vapor, and when in this condition parts with its heat much less readily than saturated or wet steam. It is not probable that the amount of superheat was sufficient in any of the cases described to fill the entire radiator with steam of this character, and this I take it accounts for the continued falling off in heat transmission as the degree of superheat increased.

The results which were obtained relating to the effect of superheated steam were quite accidental and unexpected and are, I believe, so peculiar in effect as to warrant general discussion.

The following table gives the general results of the radiator tests, which is followed with complete tables of data and results:

GENERAL RESULTS OF RADIATOR TESTS.

Radiator No. 1.

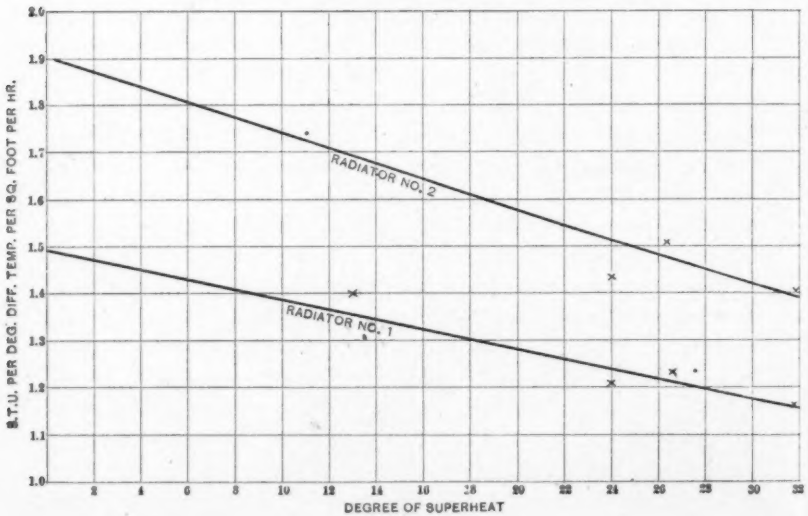
Height 18 ins. Measured surface 38.6 sq. ft. Least distance between sections ¼ in.

No. Test.	Pressure, Pounds.	Temperature Air, Degrees.	Temperature Steam, Degrees.	Degree Superheat.	B. T. U. Per Hour Per Sq. Ft. Per Degree.	Pounds of Steam Condensed Per Hour.
6	2	71.3	217.0	0	1.48	6.25
5	2	77.1	217.1	.13	1.50	8.13
4	2	74.0	252.8	35.83	1.16	7.88
7	5	70.2	239.0	13.10	1.41	9.18
3	5	75.5	252.7	24.10	1.23	8.38
2	10	72.5	264.7	26.70	1.24	9.18
8	10	75.8	238.4	.30	1.50	9.25
1	30	74.1	274.5	1.10	1.83	14.07

Radiator No. 2.

Height 38 ins. Measured surface 49.1 sq. ft. Least distance between sections ¾ in.

No. Test.	Pressure, Pounds.	Temperature Air, Degrees.	Temperature Steam, Degrees.	Degree Superheat.	B. T. U. Per Hour Per Sq. Ft. Per Degree.	Pounds of Steam Condensed Per Hour.
6	2	73.5	217.0	0	1.83	13.00
5	2	80.3	217.1	.13	1.92	12.75
4	2	77.0	252.8	35.83	1.41	12.25
7	5	73.5	239.0	13.10	1.74	14.16
3	5	76.7	252 7	24.10	1.45	12.53
2	10	74.2	264.7	26.70	1.62	15.00
8	10	77.3	238.4	.30	1.91	15.16
1	30	76 8	274.5	1.10	1 .97	18.94



RESULTS OF TEST, RADIATOR NO. 1, 18 INCHES HIGH.

Number of test	1	2	3	4	5	6	7	8
Duration of test, hours	1.33	1.5	2	2	2	1.5	1.5	1.5
Barometer, pounds	14.3	14.1	14.25	14.2	14.2	14.4	14.25	14.15
Average temperature of compartment, degrees	74.1	72.5	75.5	74	77.1	71.3	70.2	75.8
Average temperature of condensed steam, degrees	193.1	194.3	187	184.8	184.1	183.4	192	195.1
Average steam pressure above atmosphere, pounds	30.0	10	5.0	2.0	2.00	2.00	5.00	10.0
Absolute pressure of steam, pounds	44.3	24.1	19.25	16.2	16.2	16.4	19.25	24.15
Temperature of steam entering, degrees	274.5	264.7	25.27	252.8	217.1	217	239	238.4
Superheat, degrees Fahr	1.1	26.7	24.1	35.83	.13	100	13.1	.3
Weight of steam condensed, total, pounds	18.75	13.75	16.75	15.75	16 25	12.5	13.75	14.25
Difference of temperature between steam and surrounding air, degrees	200.4	192.2	177.2	178.8	140	145.7	168.8	162.2
Total heat supplied per pound of steam, B. T. U	1,165.85	1,167.33	1,162.41	1,165.31	1,147.18	1,148.3	1,157.14	1,154.72
Total heat per pound condensed steam, B. T. U	161.1	162.3	155	152.8	152.1	151.4	160	163.1
Heat radiated per pound of condensed steam, B. T. U	1,004.75	1,005.03	1,007.41	1,012.51	995 08	996.9	997.14	991.62
Total heat radiated, B. T. U	18,830	13,810	16,850	15,950	16,190	12,450	13,720	14,130
Total heat radiated, per hour, B. T. U	14,120	9,220	8,425	7,975	8,095	8,300	9,140	9,413
Heat radiated per hour per degree difference of temperature between steam and surrounding air, B. T. U	70.5	48	47.8	44.6	57.8	57.0	54.25	58.0
Same as above per square foot actual surface, B. T. U	306	239	219.5	206.5	209.5	215	237	244
Same as above per square foot actual surface, per degree, B. T. U	1.83	1.24	1.23	1.16	1.5	1.4	1.405	1.502

RESULTS OF TEST, RADIATOR NO. 2, 38 INCHES HIGH.

Number of test	1	2	3	4	5	6	7	8
Duration of test, hours	1.33	1.5	2	2	2	1.5	1.5	1.5
Barometer, pounds	14.3	14.1	14.25	14.2	14.2	14.3	14.25	14.15
Average temperature of compartment, degrees	76.8	74.2	76.7	77	80.3	73.5	73.5	77.3
Average temperature of condensed steam, degrees	194.9	190	192.4	187.2	186.9	187	194	193.8
Average steam pressure above atmosphere, pounds	30.0	10.0	5.0	2.0	2.00	2.00	5.00	10.0
Absolute pressure of steam, pounds	44.3	24.1	19.25	16.2	16.2	16.4	19.25	24.15
Temperature of steam entering, degrees	274.5	264.7	252.7	252.8	217.1	217	239	238.4
Superheat, degrees Fahr	1.1	26.7	24.1	35.83	.13	1.00	13.1	0.3
Weight of steam condensed, total, pounds	25.25	22.50	25.25	24.50	25.50	19.5	21.25	22.75
Difference of temperature between steam and surrounding air, degrees	197.7	190.5	176	175.8	136.8	143.5	165.5	161.1
Total heat supplied per pound of steam, B. T. U	1,165.85	1,167.33	1,162.41	1,165.31	1,147.18	1,148.3	1,157.14	1,154.72
Total heat per pound condensed steam, B. T. U	162.9	158	160.4	155.2	154.9	155.0	162.00	161.8
Heat radiated per pound of condensed steam, B. T. U	1,002.95	1,009.33	1,002.01	1,010.11	992.28	993.3	995.14	992.29
Total heat radiated, B. T. U	25,410	22,700	25,340	24,380	25,800	19,350	21,150	22,600
Total heat radiated per hour, B. T. U	19,100	15,130	12,670	12,190	12,900	12,900	14,100	15,050
Heat radiated per hour per degree difference of temperature between steam and surrounding air, B. T. U	96.6	79.5	71.9	69.5	94.5	90	85.3	93.5
Same as above per square foot actual surface, B. T. U	390	309	258	248	233	263	238	307
Same as above per square foot actual surface, per degree, B. T. U	1.97	1.62	1.45	1.41	1.92	1.83	1.74	1.905

DISCUSSION.

Mr. Hibbard: Have your experiments with steam at different pressures and temperatures brought any conclusion as to the most economical pressure for use in heating?

Professor Carpenter: Well, no, except I believe that we should use just as low pressure of steam as we possibly can, but in an experimental way we have not gone over that subject at all.

Mr. Reed: I understand that the test shows a high radiator to be more efficient than a low one. Do you think that the large air space had more or less to do with that?

Professor Carpenter: Yes, sir. I cannot account for these results in any other way, because several times before this we have tested radiators which were exactly the same form, supposed to have the same area of space between the sections, and we have always found the lower radiators much more efficient. In this particular case the radiators were not only of different heights but different forms, and the area of space between the sections was very small for the low radiator, and large for the high radiator; and the results quite contrary to what we had obtained before.

Mr. Paul: Couldn't that whole thing be explained by the superheat going into the water?

Professor Carpenter: We accounted for all that in the calculation.

Mr. Paul: The governing point is the condensation; if the water of condensation did not flow away from the radiator, it would be reheated by the superheated steam, and in that way you might use heat in the radiator without showing it in the condensation.

Professor Carpenter: Just ask that question again, I didn't get that.

Mr. Paul: On the inside surface of the radiator there is a film of water, and undoubtedly the superheated steam when it goes into the radiator would, because of the tendency of all superheated steam to seek moisture, heat this film and the water in the base of the radiator. And as the water in the base of the radiator would probably be practically at the temperature of the steam in the radiator, a certain amount of it would be evapo-

rated in the radiator, and as a consequence the flow of condensation from that radiator would be retarded to that amount.

Professor Carpenter: The calculation was made on the basis of the amount of heat contained in each pound of steam. Now, a pound of superheated steam carries more heat than a pound of saturated steam. But Mr. Paul raises another point which is practically this: that superheated steam tends to absorb water very rapidly and to become saturated. I used to think that such was true and I have so stated, but I have changed my mind in that respect; I think that superheated steam parts with its heat slowly and will stay superheated even in contact with water. I remember an experiment which I performed accidentally in this way: We had a glass vessel open to the air on one side so that we were certain of atmospheric pressure, and in this we placed a thermometer. We then let in superheated steam. We also put water in the bottom of the vessel, and we found that the steam above the water would remain at the temperature of 230 degrees for a great many minutes, even when in contact with the water in that little glass vessel. Since that time I have been of the opinion that superheated steam does not tend to part with its heat rapidly, nor does it take up moisture rapidly; it continues to remain like a perfect gas, as, for instance, air. It is well known that if you attempt to use air for the heating medium in a radiator, even at the same temperature as steam, you get very little heat, because the air gives up its heat very slowly. I think that in all the tests described we had a considerable amount of water in the bottom of the radiator.

Mr. Paul: Professor, the only reason I make the statement is that I have noted the pressure very carefully, and had a thermometer within five feet of the inlet valve, placed in the pipe that carried the steam to the radiator. I found that the thermometer would run up very fast while steam was being admitted, but the minute the radiator was filled and the velocity became very small the thermometer went back to its original point, the temperature due to the pressure in the pipe. The high velocity carried the superheat to the thermometer and heated it, but when the velocity became low, superheat was not indicated by the thermometer.

Mr. Blackmore: You made the statement that superheated steam did not appear to have a thirst for water; now, that is

very peculiar, because all gases when at a high temperature certainly have a great affinity for water. In your case I can readily see that the steam could not be cooled much until the water reached the boiling point, then at once, being in a condition of superheat, it would absorb it.

Professor Carpenter: Become saturated.

Mr. Blackmore: And being saturated, lose a certain amount of the heat.

Professor Carpenter: I think that is certainly true.

Mr. Blackmore: That is one of the points Mr. Paul raised.

Professor Carpenter: I didn't quite understand Mr. Paul that way.

Mr. Blackmore: I inferred from what he said that was his idea. Am I wrong?

Mr. Paul: That is the idea.

Mr. Blackmore: You were speaking of a boiler test a little while ago, and about the circulation increasing the conducting power. Now, here is a question: we undoubtedly have better circulation in the case of moisture in steam than we have in superheated steam, and if there is heat in the centre of a pipe, there must be some means of conducting that heat to the outer surface. Now, with wet steam that heat naturally would be conducted quicker than it would if the steam was superheated, and I think the difference might be accounted for in that way.

The President: Professor Carpenter, would you mind showing how the radiators were connected; the steam connections?

Professor Carpenter: We had pipe from the boiler-room some distance away, containing steam of 125 pounds pressure. We used a reducing valve which gave us a certain pressure, and then discharged into quite a large receiver. From this a large pipe, something like two inches in diameter, led to both radiators, making a single end connection. For the return water we had a drip pipe with a water glass and means for keeping the water at a constant level.

The degree of superheat was measured just as the steam entered the radiator, and later we also took the degree of superheat in some of the loops of the radiator, by measuring pressure and temperature. The degree of superheat which is given in the paper is the degree of superheat of the steam as it entered the radiator.

Mr. Davis: Didn't I understand you to say that one of these radiators was what is known as a top and bottom connected radiator—long one or a short one?

Professor Carpenter: The short one.

Mr. Davis: That I think would account for some of the difference.

Professor Carpenter: It ought to have been the other way, ought it not?

Mr. Davis: Which did you say did the best work?

Professor Carpenter: The long one.

Mr. Davis: That would be in favor of the small one.

Mr. Paul: I want to say about this matter, that you have made a statement with which I cannot quite agree; at least, I haven't been taught that way. It is that moisture on the internal surface of a radiator increases its efficiency.

Now, Peclet says that in making tests of the conducting power of iron he was obliged to sweep the surface clean of the films of water and air, and unless this was done he did not get uniform results. And I have heard it stated, I do not know upon what authority, that a film of water $\frac{1}{100}$ of an inch thick decreases the conducting power of a surface—a radiating surface—as much as one inch in thickness of iron.

I also want to say that I have found that the greater the volume of steam we put into a radiator for doing a given amount of work, the better and more efficient is that radiator. That tends to show that the sweeping or scrubbing and cleaning action of the steam increases the efficiency. Now, we have admitted that the rapid passage of air on the outside of the surface of a radiator increases the efficiency, we have also admitted that when water passes through at a high velocity the efficiency is increased, and hence it seems to me that the sweeping and scrubbing action of steam on the interior surface of a radiator is certainly a benefit.

Professor Carpenter: I think, Mr. Paul rather misunderstood my view of the matter; Mr. Paul presupposes in that instance that I put water on the inside of the radiator, which is not at the temperature of the steam.

Now, in Peclet's experiment, if you will remember, his test was not as to the effect of circulation, but was to get the conduction of heat from steam, through some metallic medium,

which is a better conductor than water. In our case, we find a very different proposition; viz., the rate of heat flow from superheated steam. I think it is a well established fact that a film of water is a great medium for receiving and transmitting heat, although not a good conductor. In a steam engine, for example, we have cylinder condensation in the inside, which is reduced or prevented by use of superheatd steam.

LXXXIX.

THE HEATING AND VENTILATION OF THE EDWARD WYMAN SCHOOL, ST. LOUIS, MO.

BY ALVIN D. REED.

(Member of the Society.)

That the proper heating and ventilation of modern schools is a matter of more than ordinary importance, is well known to all members of this society; and as there are in school houses many special features of great importance in the construction of the building, such as the arrangement of rooms and wardrobes, light, stairways, etc., which prevent the planning and erection of an ideal system, the designer is frequently called upon to exercise considerable ingenuity in planning a system which, when completed, will not only give entire satisfaction to his clients, but be entirely satisfactory to himself.

It has been my custom to keep in very close touch with the draughting room, when the planning of a new school or the reconstruction of an old building is commenced; and, in fact, the matter of heating and ventilating is always kept in mind at all stages and progress of the work. By this method a very much better system is planned than if no attention was given the heating and ventilation until all plans were finished.

In all new buildings, and when old buildings are to be reconstructed, arrangements are made to heat and ventilate by the low pressure steam and fan system. By low-pressure, I mean that not more than 15 pounds of steam is carried on the boiler, and lower pressure on the heating system maintained by reducing valves.

The cut shows one of our latest buildings, the Edward Wyman School, two stories high, the greater part of the basement floor being above the grade level. This building contains eighteen class rooms, a kindergarten and lecture room (each equal to two class rooms in area), a library, principal's office, teachers' rooms, toilet rooms, etc.

In the basement are the boiler and coal rooms, the engine and fan room, the latrine rooms, and play rooms.

Each class room is provided with ample wardrobe room, and these rooms are arranged to receive outside light. The wardrobes differ from those of the ordinary school building inasmuch as they open off of the room only, having no communication with the corridors.

The building is of fire-proof construction throughout. It is designed after the early English style, and the feeling has been admirably maintained by the use of a mottled brick with heavy gray joints. The building is finished in hardwood throughout, and the walls and ceilings are painted in lead and oil in pleasing and harmonious colors.

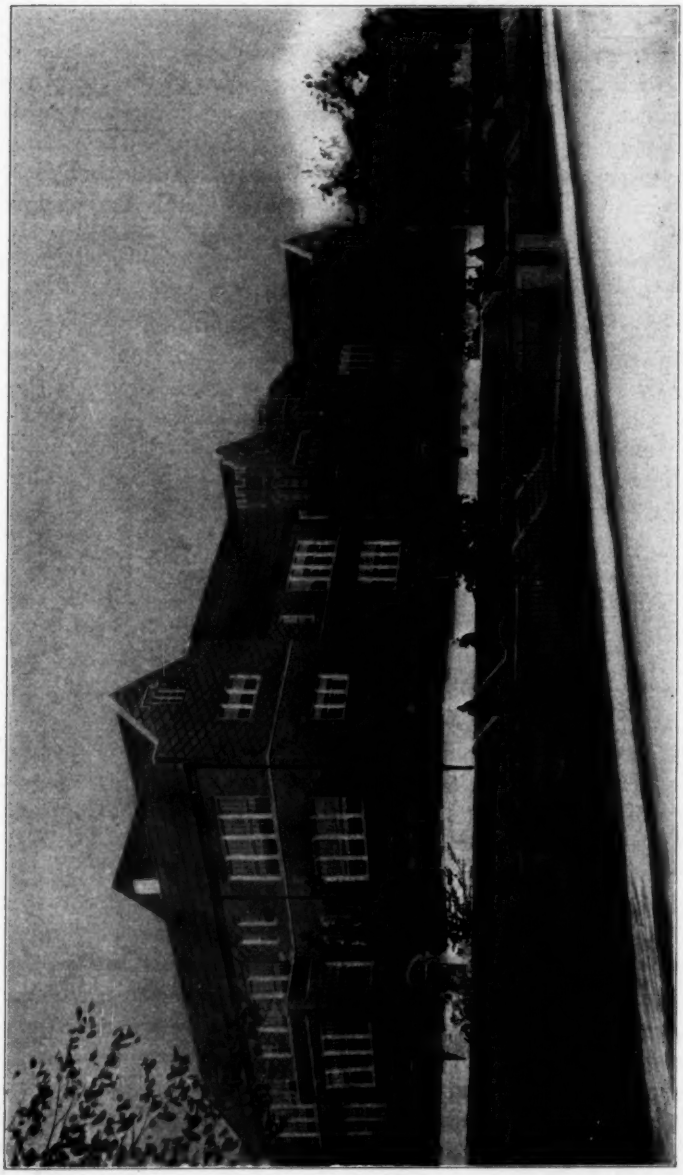
The total cost of finished building was $126,752. The cost of heating and ventilating only was $10,687.

The heating and ventilating plant consists of one horizontal tubular boiler 72 ins. diameter, 22 ft. long, containing twenty-six 6-in. flues. The engine has a cylinder 18 in. diameter by 12-in. stroke, direct connected to the shaft of the fan wheel. The fan wheel is 11 ft. in diameter by 5 ft. 6 ins. wide; and, as shown by the drawing, is somewhat different from the general method of constructing double discharge fans.

It has been designed to give an even flow of air over the entire surface of the coils, and to deliver 68,400 cubic feet of air per minute in order to comply with the guarantee. The heating of the air is accomplished by twelve coils; two coils being used as tempering coils, and five coils used in each heater stack. Each coil has four rows of one-inch pipe. The pipe are spaced 3⅛ ins. centre to centre lengthwise of the coil, and the rows are spaced 2½ ins. center to centre. The pipe are 7 ft. high, or each coil has 1,022 ft. of one-inch pipe; and the twelve coils have 12,264 ft. of one-inch pipe.

The base of this coil has been designed with a view of causing the steam and water of condensation to flow in the same direction in the base, and with a seal of water of 1½ ins. at rear end, a current of steam upward in two of the rows of pipe, and downward, as it were, in the other two rows of pipe.

During the past winter a test of the coils has proved that they do not air bind. The water of condensation is drained out of the bottom of the base as shown, giving a dry base at all times,



and is returned by gravity to a receiver, when it is pumped to the boiler.

At this school the air is drawn down through the two towers at each side of the main entrance (as shown in the cut of the building), thence through a passage way, when it passes either through or beneath the tempering coils. Under each of the tempering coils is placed a by-pass door which is caused to be opened or closed by a thermostat, placed in the tempered air room to keep the temperature of the air when it enters the fan, at 70 degrees.

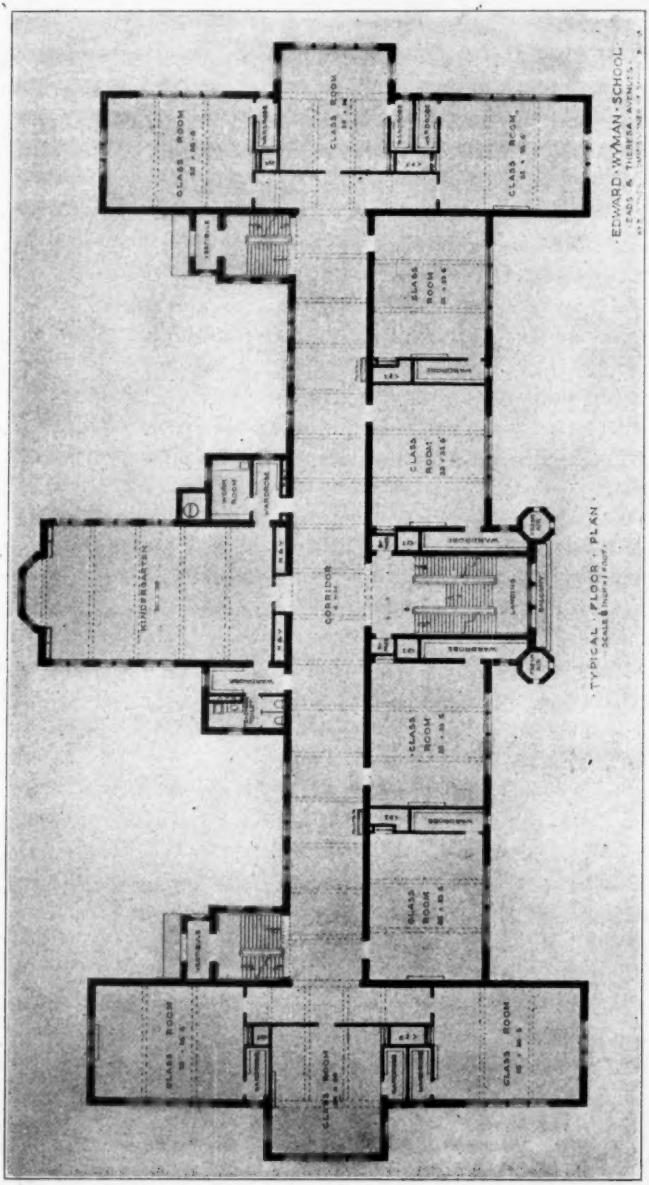
The air is then discharged from either end of the fan, either through or beneath the heating coils and into the hot room or the tempered air room, and thence into galvanized ducts hung near the ceiling, leading to each class room.

All class rooms have double connections at the plenum chamber, and these double dampers are controlled by thermostats placed in each of the class rooms. The ducts leading to the class rooms have an area of 2 sq. ft.; the vertical flues, an area of 3 sq. ft.; and the openings into the class rooms, an area of 5 sq. ft.

A diffuser is used on all fresh air openings into the class rooms. These openings are located about nine feet above the floor; and, wherever possible in the planning of the building, arrangements are made to discharge the air toward the outer walls and glass surfaces; but, as was mentioned early in this paper, this cannot always be done; and, under these circumstances, a diffuser is found to be of great value in directing the air towards the outer and, therefore, colder parts of the room. All vent registers have an area of 5 sq. ft., and are in the wardrobes at or near the floor level. This is found to give an excellent service.

The wraps of the children are hung on long hooks which prevent them from touching the walls, etc. The air passing through and around the clothing insures that it will be nice and dry when wanted for recess, or at dismissal. This is especially advantageous should the children have been in the rain or snow on their way to school.

The vent flues lead to the attic where the air is discharged to the outside through towers. Beneath these towers are usually placed two or more doors which are opened or closed


EDWARD · WYMAN · SCHOOL
TYPICAL · FLOOR · PLAN
CLASS ROOM
CORRIDOR
WARDROBE
WORK ROOM

by air pressure, handled by a small three-way cock or valve located in the engine room.

The method of opening and closing the doors in the attic has its merits; as ropes, chains, and pulleys will get out of working order; and under these circumstances it would be necessary that the janitor, in properly attending to his duties, would have to climb the stairs to the attic. This he might forget; but with only a small three-way cock to open or close, I have never found this duty neglected.

A by-pass for the whole heating system is arranged, as shown by drawing (the cut shows the actual arrangement at one of the schools, and is used here to show the general scheme in all new schools).

At the point where the fresh air enters the basement from the towers, is a door which is closed, and another door shown over the tempering coils connecting with the first floor hall, is opened. The class room doors are left open. When the fan is started, a complete circulation of air in the building is at once established. Not only is this found to be a very economical system of heating the building early in the morning, or at other times when not occupied for school purposes, but the work is accomplished very quickly.

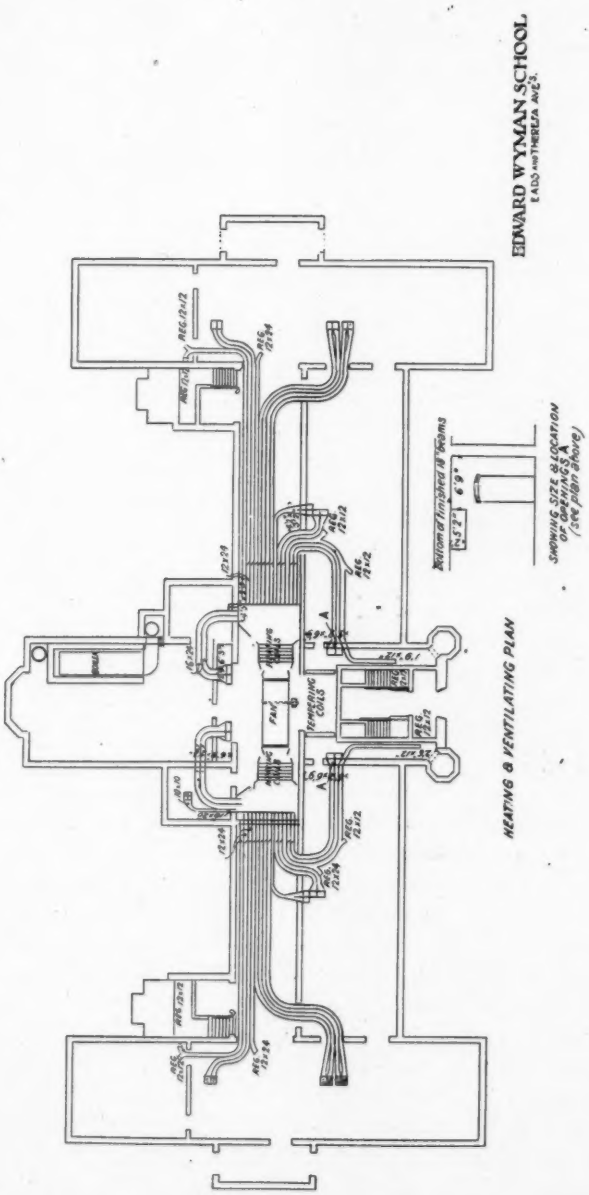
A special form of header was designed for the steam connections to the coils, in order to reduce the number of joints; and, consequently, the liability of leaks.

Formerly this header was constructed of valves and fittings too numerous to mention, with all their numerous kinks and twists in order to get them to "come right." Its advantages can be easily seen.

The heating of the halls and corridors, as well as the entire basement, is accomplished by hot air. No direct radiation is used.

The sides of the fan housing, the casing of the coils, the sides of the hot air and tempered air rooms are painted and finished in white enamel, as well as the engines, pumps, etc. The pipes, when covered, are painted white. The walls and ceilings are also painted white; and all these, when finished as described, give an idea of not only a useful apparatus, but one interesting and beautiful.

The latrines and sanitaries are also an important part of the


EDWARD WYMAN SCHOOL
LADD and THERESA AVES.
HEATING & VENTILATING PLAN
Bottom of finished of Beams
SHOWING SIZE & LOCATION OF BEAMS
(See plans above)
FAN
TEMPERING COILS
REG. 12x12
REG. 12x24

fitting up of a modern school house. Each of the closets shown has a local vent of 7 square inches, connected to an underground duct leading to the space around the cast iron stack. The urinal stalls are also ventilated in the same manner, each stall being separately ventilated into the underground duct.

We have a special arrangement for keeping a fire in the stack in warm weather when there is no fire in the boiler, insuring perfect ventilation at all times.

DISCUSSION.

Mr. Folsom: Where does the air escape?

Mr. Reed: Into the attic. There is one escape for air here (indicating), and one on the opposite end of the building, and then there are two very large escapes on the rear side.

Mr. Folsom: Are those in the attic in the roof or in the side of the roof?

Mr. Reed: Two are in the top of the roof and two are on the side of the roof.

Mr. Wilkes: Do you ever find that you need to use screens for the fresh air?

Mr. Reed: We do not.

Mr. Wilkes: We find we have to in large cities.

Mr. Reed: Well, in the downtown schools screens might be used to an advantage.

Mr. Wilkes: What is the temperature of that air after it passes through the coils?

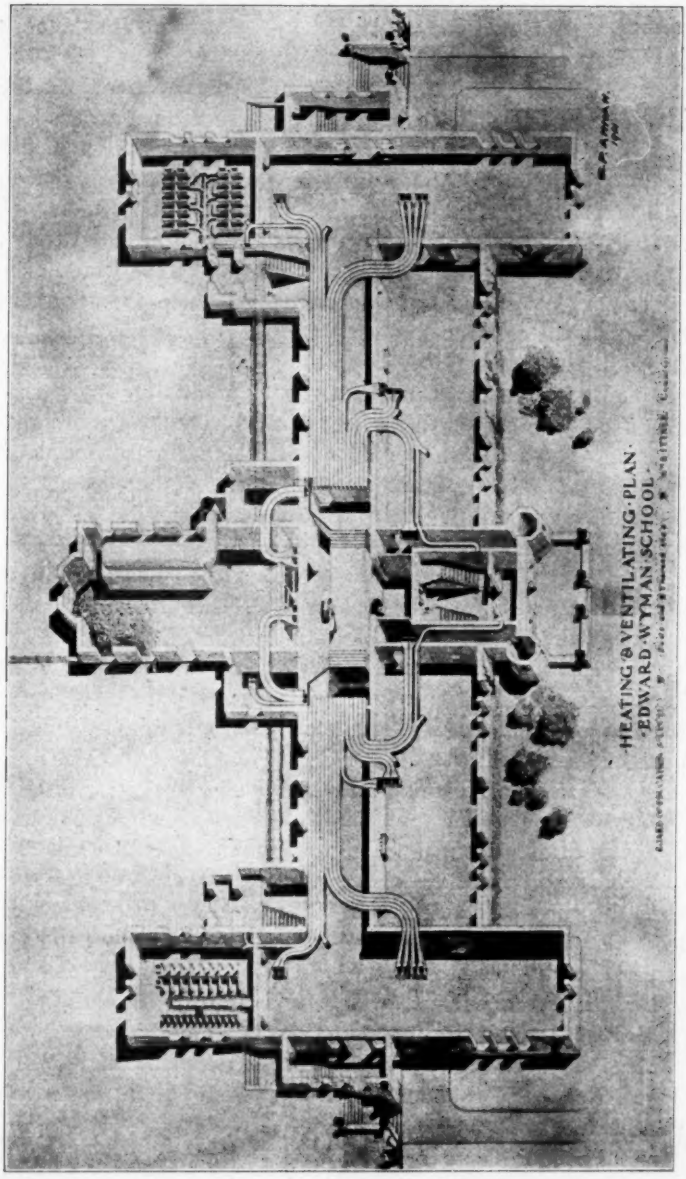
Mr. Reed: We get very good satisfaction out of about 140 degrees temperature in the hot room, in very cold weather.

Mr. Wilkes: What is the loss of temperature when it reaches the outlet to the room?

Mr. Reed: In one of the schools I made a test last winter, when it was very cold; and, it happened to be an exceptionally long run of pipe, and lost 30 degrees. We don't lose more—probably not more than 20 degrees on an average to where the air enters the class room.

Mr. Wilkes: About what is the outside temperature when you have all of the coils steamed up and the by-pass closed; at what outside temperature do you have to use all the coils?

Mr. Reed: We generally use them all in the morning, that is


HEATING & VENTILATING PLAN
EDWARD WYMAN SCHOOL

down to say ten o'clock, until the time we get the building thoroughly warmed up, and then, as it gets warm, cut the coils out, as fast as opportunity permits.

Mr. Wilkes: Wouldn't it be better if the air went out the back of the room instead of going through the wardrobes?

Mr. Reed: I don't know that that makes any particular difference. The object of having it in the wardrobes is to bring a circulation of air around the clothing.

Mr. Wilkes: Does the teacher sit at the window end?

Mr. Reed: That depends on the location of the windows in the room. We always seat the rooms so the windows are at the left side of the children, and the teacher of course sits facing the children.

Mr. Mackay: In that particular case you are showing, the air would be traveling towards her, in that particular room that you illustrate there; she would sit next to the wardrobe door.

Mr. Reed: The fresh air is coming in above her head.

Mr. Hartman: What steam pressure have you in the coils in cold weather?

Mr. Reed: Three pounds was as much as we had last winter.

Mr. Hartman: What is the principal reason of having such a low boiler pressure?

Mr. Reed: Why, in keeping it below 15 pounds of steam we keep within the city ordinance in such a way that we do not have to employ a licensed engineer, although we have quite a number of them.

Mr. Hartman: How fast do you run that fan?

Mr. Reed: That fan runs about 125 revolutions per minute.

Mr. Paul: How much coal does it take to heat that school?

Mr. Reed: About 6,000 bushels per winter. That is soft coal, the cheapest kind of coal. The contracts for coal are let to the lowest bidder, and we are paying 6½ cents now; and you can guess what we are getting.

Mr. Paul: The exhaust of the engine remains?

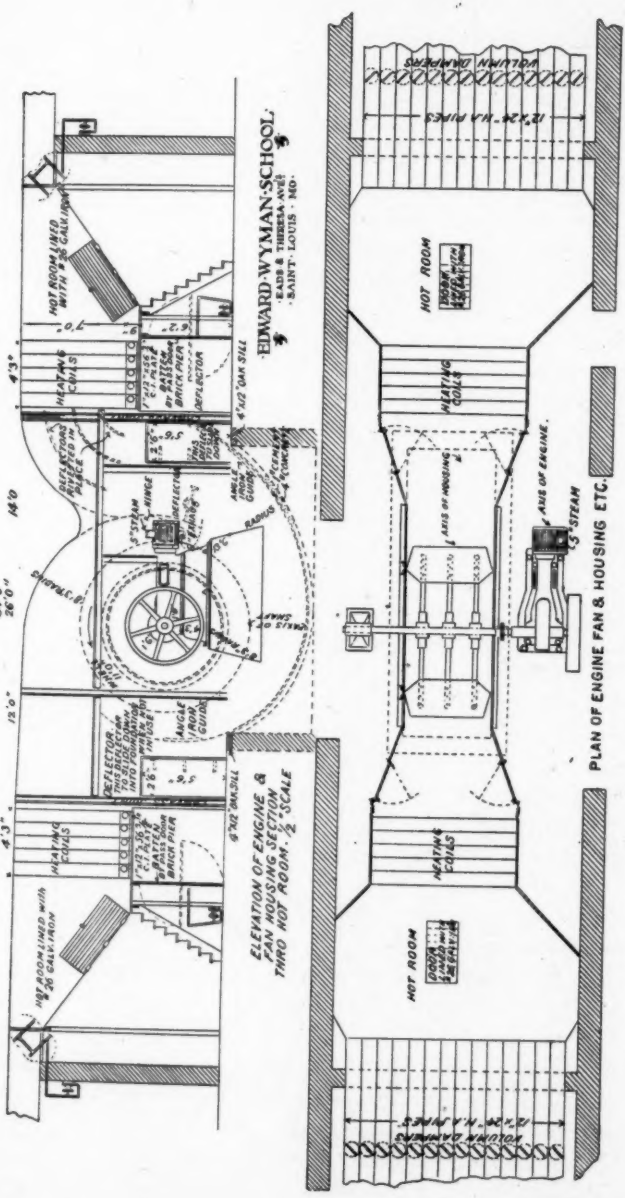
Mr. Reed: Yes.

Mr. Paul: Having 3 pounds of pressure on the engine?

Mr. Reed: Yes, about that, increasing it in very cold weather.

Mr. Paul: What makes you increase the boiler pressure?

Mr. Reed: To overcome the back pressure.


EDWARD·WYMAN·SCHOOL
·EADS & THERESA AVE.
·SAINT· LOUIS · MO·
ELEVATION OF ENGINE & FAN HOUSING SECTION THRO HOT ROOM. ½ SCALE
PLAN OF ENGINE FAN & HOUSING ETC.
HOT ROOM
HEATING COILS
VOLUMN DAMPERS
12"x24" HA PIPES
AXIS OF ENGINE
AXIS OF HOUSING
STEAM

Mr. Paul: Did you add additional pressure to your engine to overcome that?

Mr. Reed: Yes, sir.

Mr. Wilkes: Did you ever have any complaint about varying temperatures?

Mr. Reed: I have not.

Mr. Wilkes: Do you use as low a velocity as you can possibly get the room heated with, is that it?

Mr. Reed: That is it, to keep the velocity down as low as possible. There are some places where in heating the halls we get a very high velocity.

Mr. Folsom: I will ask Mr. Reed, if that air moving from these rooms or these halls into the study rooms, if there is any perceptible feeling of draught that you know of on the floors or near the floors?

Mr. Reed: No, I haven't had any complaint of it.

Mr. Folsom: Of course, this afternoon the subject was brought up about measuring the velocity of the air, and it was in that connection I was wondering if it was perceptible; sometimes it will be indicated and sometimes it will not.

Mr. Reed: I tried an anemometer, set it right in the door between the class room and the wardrobe where the air passes through, but the doors are so large, the average size with us 3½ x 7 feet, so that it is passing through such a large opening that the velocity is very low; it is hardly perceptible.

Mr. Hartman: Mr. Reed, do you consider the velocity of the air in the ducts in proportion with your heating surface? I mean, do you take into consideration that your air moves slow or at a high velocity, in order to determine the amount of heating surface?

Mr. Reed: No, I determine the amount of heating surface by the quantity of air to heat.

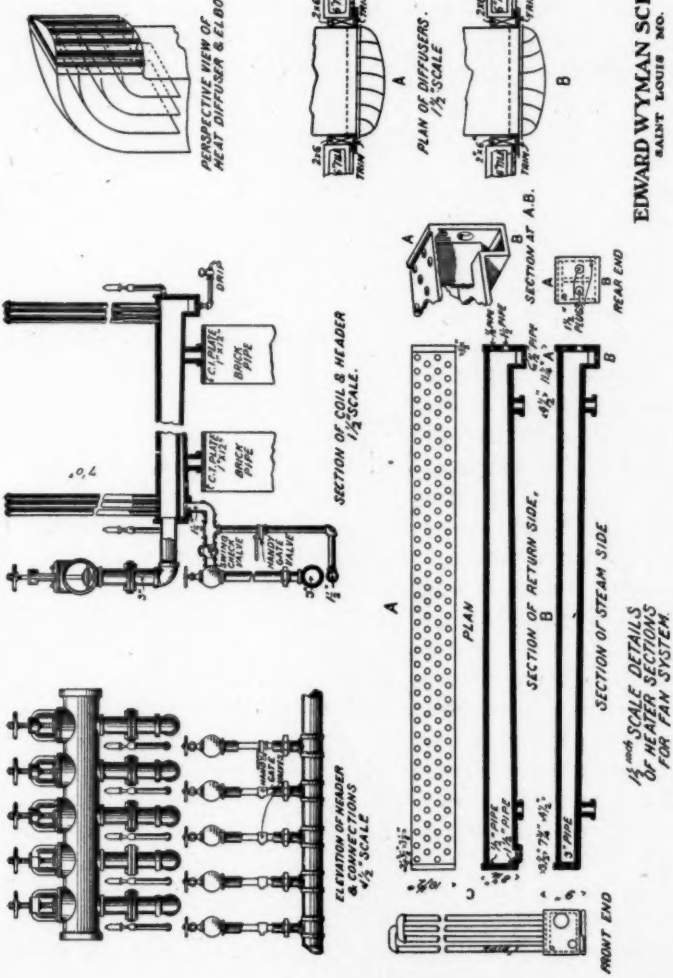
Mr. Hartman: Naturally, with a slow velocity of air in the ducts you lose more of the temperature than you would with a high velocity?

Mr. Reed: Yes.

Mr. Hartman: And consequently the slow velocity would require more heating surface?

Mr. Reed: Perhaps, that is so.

Mr. Wilkes: The temperature of the basement was at least 70 degrees all the time.


PERSPECTIVE VIEW OF HEAT DIFFUSER & ELBOWS
PLAN OF DIFFUSERS. 1/2 SCALE
SECTION AT A.B.
SECTION OF COIL & HEADER 1/2 SCALE.
ELEVATION OF HEADER & CONNECTIONS 1/2 SCALE
PLAN
SECTION OF RETURN SIDE.
SECTION OF STEAM SIDE
FRONT END
REAR END
EDWARD WYMAN SCHOOL
SAINT LOUIS MO.
1/2 inch SCALE DETAILS OF HEATER SECTIONS FOR FAN SYSTEM

Mr. Reed: We kept the whole house at 70 degrees. We heat the basement and halls and corridors and play rooms.

Mr. Wilkes: Did you ever make any experiments with regard to the air through those coils and delivering it into the ducts?

Mr. Reed: No, sir.

Mr. Hartman: As to the resisting pressure?

Mr. Reed: I did, but I was lucky enough to lose it.

Mr. Macrum: About what power does it take to convey this air in this particular school?

Mr. Reed: About 30 horse-power.

The President: We would like to have some of you who have had experience in that line tell us about it. I do not think, that Mr. Whitman is present, but I see Mr. Kimmerly of St. Paul is here. I would like to hear from you, Mr. Kimmerly.

Mr. Kimmerly: Mr. President, I don't think that I could add anything to what Mr. Reed has already said; only I would ask Mr. Reed if he has ever made any comparative tests in regards to the cost of operating a fan system over that of direct radiation or indirect?

Mr. Reed: I have not. I know the cost is a little more for coal, and I couldn't say now just exactly what it is. I know in the cost of fuel the fan jobs are the highest, and I believe the indirect radiation comes next, and then the direct-indirect. All the schools in which the different systems are in use, are put together and the average cost is arrived at in that way.

The President: How does the cost for running the fan system compare with the cost of some of the older buildings where you have furnaces?

Mr. Reed: Last year the cost of the fan system was about 20 cents per class room less than the hot air furnaces.

The President: You say 20 cents less per class room?

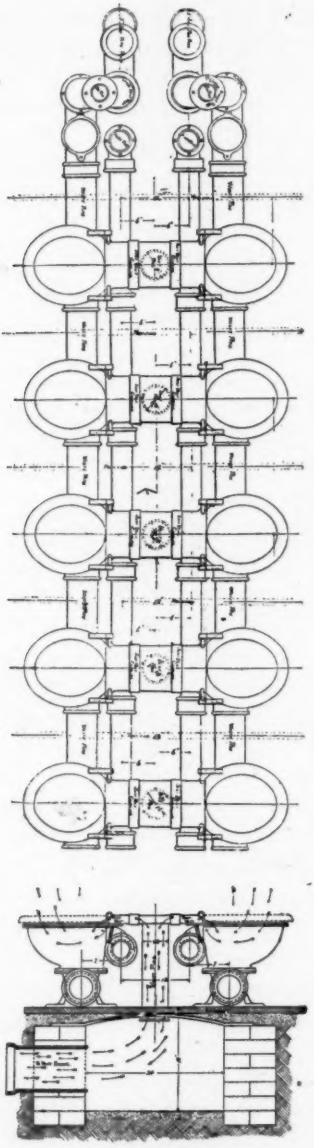
Mr. Reed: Per class room, yes; we went over the figures four or five times, and I know just how many bushels of coal went to every school.

Mr. Wilkes: For what time?

Mr. Reed: The entire season.

Mr. Wilkes: On the basis of moving the same amount of air.

Mr. Reed: With the hot air furnaces the flues are small, and the class rooms do not get the same quantity of air as in the schools where fans are used.



END VIEW
SHOWING BRICK AIR DUCT
ARROWS INDICATE DIRECTION OF AIR CURRENTS.

Mr. Wilkes: Don't you reduce them to the same basis?

Mr. Reed: No, not quantity of air, simply heating a given number of class rooms.

Mr. Mackay: Are any of your hot air buildings run with fans?

Mr. Reed: We have one, a small school away out in the suburbs, it is pretty close to the World's Fair grounds, and I expect to take it out next summer; I have taken out two the last year, and one the year before.

Mr. Mackay: How does the furnace system with fans compare with the furnace system without fans with you?

Mr. Reed: Well, the difference in construction, of course, is very great. We keep the school heated where furnaces are in use without fans, but that particular school that I spoke of we had to dismiss the scholars very often in cold weather. Probably part of that was due to very poor workmanship and method of erection; it might not have been the fault of the furnace altogether, but the workmanship was of the poorest possible character.

Mr. Mackay: Did you move more air than you could heat?

Mr. Reed: Yes.

Mr. Mackay: Do you think that adding a fan to the furnaces that were fairly satisfactory would have improved them?

Mr. Reed: No, not the way ours were constructed.

The President: There is a thermostat in each room, is there not?

Mr. Reed: Yes, sir.

The President: Have you been able to try intermittent thermostats?

Mr. Reed: Do you mean slow moving?

The President: Yes, those that take intermittent positions?

Mr. Reed: No, I have not. We had some of them in on two or three schools, and we tried them on one furnace job to see if we couldn't get better satisfaction out of them, but they seemed to get out of order; they don't seem to give us satisfaction, at least not the satisfaction that I expected out of them.

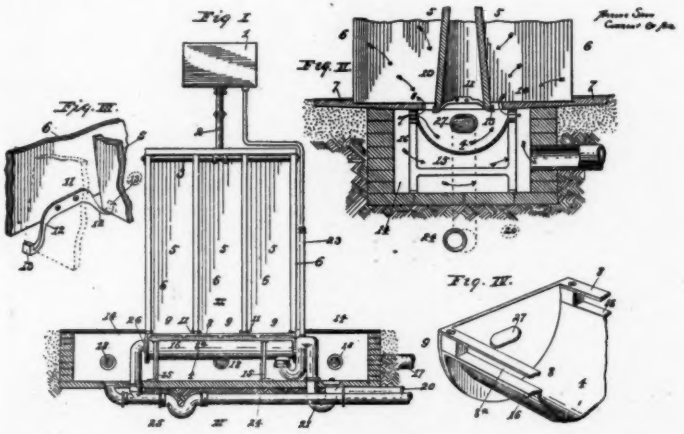
The President: If you put the thermostat up in such a manner as to make it act slowly——

Mr. Reed: That is the way they tried to do this as I understand it.

The President: And they didn't work satisfactorily that way?

Mr. Reed: No. We got a lot of regulation in, we had the old style which was partly electrical and part pneumatic, and it doesn't give us quite the satisfaction that it ought to, but we have a lot of pneumatic regulation that does give good satisfaction.

The President: Do you have any complaint of teachers, who move out of schools heated by direct radiation into schools that are heated and ventilated by the fan system, to the effect that when the temperature says it is 70, they are colder than they would be in a room heated by direct radiation at 70?

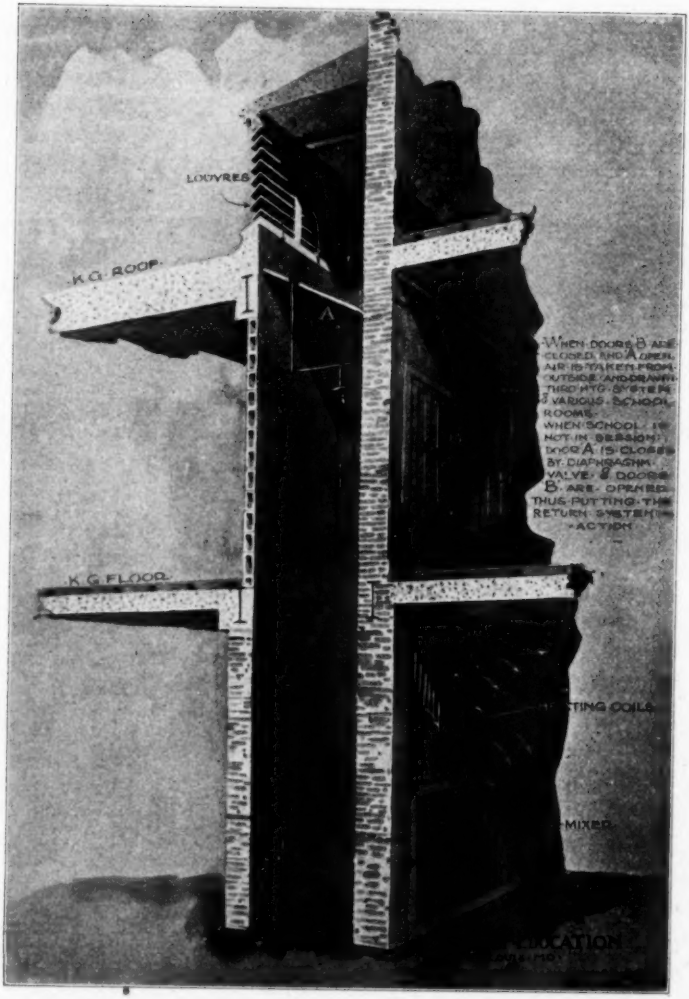


Mr. Reed: Yes, but I think that is prejudice or imagination, I don't know which. I have taken teachers down stairs into the cellar and showed them where we take the fresh air in, and then into the hot room and showed them where it enters the ducts going on the way up stairs, and they say, oh, yes, that looks very nice, but I don't believe it; doesn't seem to satisfy them that the air is pure. We tried a humidistat in one of the new schools last winter, and I am rather inclined to believe we got very good satisfaction out of it.

The President: Could you in that school carry a lower temperature than 70 degrees and yet satisfy the teachers?

Mr. Reed: I believe we can.

The President: They would feel as warm as though it was 70.


LOUVRES
K.G. ROOF
K.G. FLOOR
WHEN DOORS B ARE CLOSED, AND A OPEN, AIR IS TAKEN FROM OUTSIDE AND DRAWN THRO M'G SYSTEM TO VARIOUS SCHOOL ROOMS.
WHEN SCHOOL IS NOT IN SESSION DOOR A IS CLOSED BY DIAPHRAGM VALVE & DOORS B ARE OPENED THUS PUTTING THE RETURN SYSTEM IN ACTION
TING COILS
MIXED
LOCATION

Mr. Reed: I think dry air has a great deal to do with it; I think we will be able to reduce the temperature several degrees. Just exactly how many at present I am unable to say.

Mr. Wilkes: I can sight a case in a school where the pupils of the age of eight or nine years old, all they wanted was a temperature of 66, and the others fifteen or sixteen years old, they wanted 70, especially after recess and they came in thoroughly heated up, and they were cold at 70, when the others were hot at 66.

XC.

VOLUME OF WATER IN HOT-WATER HEATING APPARATUS.

BY W. M. MACKAY.

(Member of the Society.)

The volume of water required per square foot of radiating and heating surface, in the radiators, mains and heater, in a hot water heating apparatus, for best results in heating, and greatest economy of fuel in operation, is a question which has received some attention in the past, but judging from the differences of opinion, as expressed in their various constructions, by manufacturers of heaters, which have been used for heating by hot water, during the past twenty-five years, and which are being offered and used at the present time for that purpose, we are still far from a standard, particularly in the volume of water required in the heater per square foot of heating surface exposed to the fire or heated gases.

In the manufacture of radiators, particularly when they have been constructed with a view to their being used for hot water heating, the standard aimed at, and finally accepted, by the leading manufacturers of radiators, in this country, has been one pint of water to the square foot of surface—being approximately the volume of water contained in one square foot of surface of one inch ordinary thickness wrought iron or steel pipe.

Some radiators have been constructed which contained less than this volume of water, and some which contained considerably more, but in either case these radiators have gradually gone out of use, while new designs in hot water radiators which have been brought out during the past six years, have largely conformed with this standard, which seems in practice to be the best suited for this purpose for all classes of buildings, except perhaps all glass constructions, in which I have found it to be an advantage, on account of the greater and quicker cooling effect in such constructions, and the variable temperatures at which

the water in the system is sometimes maintained, on account of irregular firing, lack of fire-box capacity, or lack of capacity in the heater, and on account of friction due to the long lines of piping usually employed in placing the required radiating surface in this class of building, to use a surface that contained from fifty to one hundred per cent. more water, although were a uniform temperature maintained on the water in the heater, and the same arrangement of radiating surface utilized that is at present used for the heating of other buildings with this system, with short circulations, and an ample arrangement of mains, it would not be necessary to increase the body of water in the radiating surface in such constructions above one pint to the square foot of surface.

At our last annual meeting, during a topical discussion, when this question was under consideration, I mentioned an experiment, or test, made some years ago, in two green houses of uniform construction, size 16 x 100, each house contained approximately 2,000 sq. ft. of glass, and had about 650 sq. ft. of surface or running feet of 4-in. green house pipe, each house was heated by a separate heater located in the same pit with separate brick flues, 8 x 12 ins., extending 20 ft. above the ground, to these flues each heater was separately connected by 10-in. wrought iron pipe, each heater had about 4 sq. ft. of grate area and about 90 sq. ft. of fire and flue surface (about half fire and half flue surface), the radiating surface was arranged in the usual way for such constructions, in 4-in. green house pipe on each side of the house, below the benches, with one flow and two returns pipes on each side, an open expansion tank at the extreme end of each line, and each side connected separately to the heater with a 4-in. flow and return connection. In one house the 4-in. pipe was left regular and had an internal area of about 10 sq. ins., in the other house, 2 x 2 ins. oak strips were inserted in the centre of the pipes, reducing the waterway about 40 per cent., while retaining the same external surface. In a six-hour test maintaining a 60-degree temperature in each house with an outside temperature of from 25 to 30 degrees, an average temperature of 160 degrees was maintained on the flow mains, and 130 degrees on the return mains at each heater. The consumption of fuel was 130 pounds of anthracite coal, stove size for the house with full waterways in the radiating sur-

face, and 110 pounds of the same coal for the house with reduced waterways, while the temperature on the flow main on the heater with reduced waterways was frequently 5 degrees higher than on the other heater, and the dampers on this heater had to be partially closed to prevent a higher temperature, later this house was lengthened 25 feet, or 25 per cent., and piped in the same way, and the temperature maintained with the same average consumption of fuel, as that used in the other heater on 25 per cent. less surface and glass area.

Since that time, I have used largely 1¼-in. pipe, with a little over one pint of water to the square foot of surface, in small conservatories, 1½-in. pipe with about 1½ pints of water to the square foot of surface, in medium-sized conservatories, and 2-inch pipe with about one quart of water to the square foot of surface, in large conservatories and green houses, in preference to 4-in. green house pipe, with about a half gallon of water to the square foot of surface, and have found that I obtained better and quicker results, a greater possible variation of temperature and greater economy, from the use of 2-in. pipe with manifolds, than from any other size of pipe, either larger or smaller.

In arranging the mains of a hot water heating apparatus the area of the main has to be determined from the number of square feet of radiating surface to be supplied, and the nature of the surface, whether direct, direct-indirect, or indirect radiation, and from the length of the main, also whether the main is

to be used as radiating surface, or covered, so that no standard as to volume of water per square foot of surface supplied, could be adopted in regard to the mains in a hot water heating apparatus, without being subject to considerable variation, at the same time I have found cases in hot water heating where the area of the mains were from 25 to 50 per cent. larger than was necessary, and they could have been reduced with beneficial results, being made large to ensure a uniform temperature in the main, which could have been obtained in a smaller main with a different arrangement of taking off branch connections.

The greatest difference of opinion as to the volume of water required per square foot of its surface, in hot water heating, seems to exist in the heater, or source of supply.

Commencing with boilers of the Cornish type, which are used in some sections for hot water heating, they contain about 3 gallons of water per square foot of boiler surface; then the ordinary horizontal and vertical tubular boilers arranged for hot water have about 1½ gallons of water per square foot of surface, a number of cast iron one piece and sectional heaters have about one gallon of water per square foot of surface, some have three quarts, and others have half a gallon; then some heaters of this type, and water tube heaters, contain from three pints to one pint of water per square foot of surface, and in some heaters, constructed of one-inch pipe, while the volume of water to the foot of surface is not materially reduced, the friction is increased by inserting a sheet metal circulating division reducing the pipe to half its area. Now, if we do not consider the Cornish boilers, which are more largely used in other countries, and commence with the horizontal tubular boiler, which is largely used in this country, we have a variation in hot water heaters of all the way from 1½ gallons to one pint of water, per square foot of surface, and while all of these different constructions, with their varying amounts of water, will accomplish certain results with more or less efficiency and economy, certainly some will produce better results than others, and on that account would be considered a proper standard, and while the arrangement and location of the surface, to the fire and heated gases, would make some difference as to volume of water which should be back of it, I have obtained the best results from an average of a half gallon of water per square foot of heating

surface in a hot water heater, with an average of from 20 to 25 sq. ft. of heating surface to each square foot of grate area; the surface being arranged about 50 to 60 per cent. of fire surface, and about 40 to 50 per cent. of flue surface.

DISCUSSION.

Professor Carpenter: It seems to me that the paper is to be commended as bringing out a great deal of information on the subject of the relation of the heating and volume surface in boilers, to that in radiators, as there is no doubt, but, that this ratio plays an important part in the successful operation of a heating system. If the volume within the heater be too small, the circulation is likely to be bad, particles of water are thrown out with the steam, and the results are poor.

The President: Any one else have anything to say? I hope the visitors will bear in mind that we want to hear from them. We have a gentleman with us who is connected with the American Radiator Company, Mr. C. B. Thompson. Mr. Thompson, won't you say something about this?

Mr. Thompson: I am very much interested in Mr. Mackay's paper, having given the subject considerable thought.

While I have no exact data in regard to the ratio of water to heating surface in boilers, I have seen enough to convince me that a great many water boilers contain entirely too much water.

I have noticed that where the water ways were thin and the circulation unimpeded, the per cent. of available calorific power was much higher than where the water ways were large and the circulation slow.

The heat transmission per square foot of heating surface is always higher in the boiler with thin water ways.

I believe, manufacturers make a mistake when, with the exception of a deeper dome, they make the same boiler for water and steam.

In designing such a boiler, the water heater is wholly overlooked, and of necessity; because the designer must always keep in mind that the boiler will be used for the generation of steam, and must be so constructed as to have a steady water line, and carry the required pressure without priming.

I believe a water boiler should be so constructed as to present a large proportion of the heating surface to the direct rays of the fire, because a low fire is carried so much of the time. It should have thin, unimpeded water ways which induce rapid circulation and a high transmission of heat.

In the absence of any exact data, I am disposed to accept Mr. Mackay's estimate of about four pounds of water per square foot of heating surface, as a good rule to follow in designing water heaters.

Mr. Reed: Do I understand that by the insertion of an oak strip in the tube that there was an increased efficiency of 25 per cent.?

Mr. Mackay: No.

Mr. Reed: After you built 25 feet on to the green house, didn't you use any more coal than you did before?

Mr. Mackay: That was not a test, that was an assertion by the owner, but the previous one was a test where the difference was 110 to 130 pounds, 20 pounds of coal in six hours, or a saving of 18 per cent. in fuel for the same work, with the volume of water reduced from a half gallon to a quart per foot of radiating surface.

The President: Both Mr. Mackay and Mr. Thompson have touched on the question of economy. I believe, Mr. Mackay said, that he thought two-inch pipe was the most economical, did you not, Mr. Mackay?

Mr. Mackay: Yes, sir.

The President: Now, you, Mr. Thompson, spoke of the economy, too; can you say something further about that. I should like more information.

Mr. Mackay: I should like to enlarge upon that subject for a minute. As I mentioned in my paper 4-in. green house pipe has for perhaps forty or fifty years been the accepted radiation for green houses, and it is only within the last few years that attempts have been made to use smaller pipe, and the results have been to those who have tried it more beneficial in getting quicker circulation and also in economy, and one of the reasons for that is that on account of the amount of exposure in a 4-in. cast iron pipe, you cannot control your surface as well as you can in a smaller body, the smaller body can be raised quicker and lowered quicker, and with the variation of temperature

outdoors and the help of the sun, greenhouses require little or no heat during the daytime. Now, with 4-in. pipe there is only one remedy, and that is to waste your heat to the outer air by opening the ventilators which are provided on all green houses, and that is a consumption of fuel without the possibility of utilizing it, consequently it is a waste. You can lower your temperature quicker with a 2-inch pipe, and you do not need to open the ventilators, and you do not have to waste your heat through the top of the house.

Some remarks were made at our last annual meeting on the advantages of storing heat, but I think it is better to generate your heat as you require it and use it as you generate it, and with sufficient capacity in your boiler and sufficient capacity in your fire-box for fuel, there is no necessity of variation in temperature.

In the heating of buildings some have raised the objection to hot water, on the point that it takes it too long to get it up in the morning, that the fire was banked at 9 or 10 o'clock at night, and that in the morning the building was 50 degrees, when it should have been 70, and that it was ten or eleven or twelve o'clock before that temperature, 70 degrees, could be reached, and that that was a disadvantage. I have not found it so in properly placed and properly operated apparatus. I tell people not to let the fire or the hot water get to too low a temperature at night, but to keep it up, and in using it myself for years I burn more coal at night than I do in the daytime. Green house men do exactly the same thing, they only burn coal at night and bank their fires in the daytime, so that it seems to me a wrong use of the heating apparatus that has given it that objection.

The President: When you refer to 2-inch pipe, Mr. Mackay, do you mean, use 2-inch pipe with an open heater or a closed heater?

Mr. Mackay: Open, mine has always been open. I can get better results with an open system with less pressure and better circulation. Of course, I don't always put my tank on the same level. I have felt it objectionable, dangerous, and a bad practice to use a high pressure when you can do the work with a low pressure.

XCI.

TOPICAL DISCUSSIONS.

TOPIC NO. I.

" What do you think of the system of calling for specifications and estimates, without making any honest attempt to pay any remuneration to the engineer who answers the call ? "

Mr. Wilkes: I think it is a case of old dog Tray. If we had a lot of work to do we wouldn't make them. When there are twenty-five steam fitters and just one job, they will make all the plans wanted, but if you have twenty-five jobs running and one steam fitter, he will make none.

Mr. Blackmore: I think, instead of at the semi-annual meeting, if at the annual meeting, when more members are present, it would be well to discuss it, but it is pretty much as Mr. Wilkes says.

There are a great many more engineers now to make plans and specifications than there were ten years ago. I don't think anything could be done at this meeting to forward that object; I think, it is a question of time and education.

Mr. Wilkes: I will say in this connection, I notice on large work that the bids run very much closer where they all bid on the same plan, than where they submit their own plans. I have in mind now one building on which the bids vary from about $96,000 to about $104,000, on an estimated cost of $100,000, and I have seen them run closer than that even on large plants in that class of work, I have no definite information as to why they run so close, unless it is that they all figure on using the same amount of material, and that it is a mere matter of judgment as to how much labor will do the work, and how much a man is willing to take; the amount of material is the same with all of them, or should be at least.

Mr. Paul: I wish to say, Mr. President, that this question

was up before the Master Steam Fitters' Convention, and some very strong language was indulged in as to the harm that is being done, and also the injustice; but there was not anybody there who had a remedy to propose that was practicable, or that could be put into effect, and the matter was given up as a bad job for the time being.

Mr. Mackay: I would state, Mr. President, that one of the prime objects in organizing this society was to take care of that particular point, and it is put down eighth among the objects of the society in our constitution. "To establish a uniform scale of prices for all professional services." Nothing was done for a number of years, except as we are doing now, in topics, but some three years ago a committee was appointed to confer with the American Institute of Architects on this subject. The chairman of the committee is Mr. Jellett, Professor Carpenter is one of them, and I believe, Mr. Adams, of Baltimore, is the other. They brought in a report at the last annual meeting, which shows that the architects of the United States realize the justice of the assertion that the engineer should be paid for his plans, and their society appointed a committee to confer with our committee, and I believe that before our next annual meeting that committee will have a report that has been adopted by the American Architects, and the engineers that on work that the engineers are engaged in they should be paid a certain amount, which I understand their suggestion was would be added to the architect's fees, not deducted from the architect's fees. That is, as I understand it, so that our society has been moving along those lines. We believed that those gentlemen should help to regulate this matter, and we have been well received by them. We have inserted an entering wedge on a line that will eventually lead up to some solution of the problem. Of course, willingness of contractors to make plans and specifications for nothing, regulated by the amount of trade that they have, as our friends here suggested, would be a hard one to overcome, but I think, in time that that can all be taken care of, and that they will look on their draughting room as unnecessary in their business, an unnecessary expense, and that the engineer will make the plans, and the contractor will take care of the work, and the architect and the owner will pay the engineer for his plans.

Mr. Wilkes: The space in large buildings required for the engineers' work is lost sight of in the design.

When allotting a space in which the contractors for plumbing, ventilating, steam-fitting, etc., are to place their work, every man is working for himself whenever the work is not laid out by an engineer. In all these large office buildings we installed plants up to 2,000 horse-power capacity, working under pressures of as high as 150 pounds per square inch, and it is readily seen if the work is not laid out beforehand that the different interests will clash, if the problem is left to the individual contractors to solve.

There are always two ways of doing a thing and doing it right, but if the layouts are left to the different contractors, it is readily seen that the plumber will not look out for the steamfitter; or vice versa, and the one that gets in the building first takes the space best suited for his own work, without caring for the others.

This shows the necessity of having the problem thoroughly solved, and plans made by an engineer before the work is started; because I have often had a contractor bring up the changing of the location of his work and not understand why it could not be done, until it was shown to him that other pipes as well as his own were to be installed in that immediate vicinity, and that to change would cause a great deal of interference with other work simply to accommodate him by making the changes he suggested.

Mr. Wilkes: While this is not to the point: I want to mention some other work. You remember the old story about the sea captain, who was asked why he didn't throw his bread upon the waters, and he said he didn't want to, because it would come back too salt; but, I think about three years ago, Mr. President, you cast your bread upon the water, in a paper in "Heating and Ventilation," regarding the effect of large volumes of air passing through galvanized iron ducts exposed to the outside atmosphere. Now, I had a case where ducts carried in the neighborhood of 17,000 cubic feet of air per minute through a temperature of about 40 degrees for 80 feet and then it delivered into rooms. I saw your paper at the time and thought I would just test the formula and see how close it would come out, and it came out within two degrees of the

figured temperature. Not knowing, but, that others might not have had an opportunity to test it, I want to say, that I think it a very good formula, and I have since used it in several cases and it runs very close; much better than guessing.

The President: Of course, I am much obliged for what Mr. Wilkes has said, but I was going to call him to order because I did not know how the story would turn out. He was not discussing the subject before the society, but I am glad I didn't call him to order.

TOPIC NO. 2.

The advisability of the adoption of the Metric System.

Professor Carpenter: Mr. President, as nobody else desires to discuss the subject, I will say a word or two. There are numerous arguments both for and against its adoption. Our present system affords intellectual culture, as all have to do some mental work to perform calculation and obtain correct results. That may take a little extra time, but it sharpens up the faculties of the mind of many a man who has not other mental work. Professor Unwin once told me that the English money, which has pounds, pence, and shillings, was of unquestionable value to the youngsters of England, for the mental discipline it gave; he said if it were not for that money there was a certain class in England that would have no mental drill at all. There is a good deal in the above argument, as it don't do a bit of harm to have some calculating occasionally. As a matter of fact, the saving of time with the metric system is much overestimated, as the calculation is done largely with tables and the unit most in use, be it a foot or an inch, is subdivided decimally. The cost of the introduction of the system would be enormous, as it would necessitate a change in nearly all our standard tools. The advantages of the metric system are well known and much talked of, but there are two sides to be considered in its adoption.

Mr. Blackmore: I differ entirely from Professor Carpenter. If Professor Carpenter could demonstrate that the American youth brought up on dollars and cents is worse off for that than the English youth on pounds and shillings, I will admit the proposition. I believe in simplifying everything we have in life

and in saving all the work we can both mentally and physically, and if there is anything we can introduce to simplify our method I would prefer it. I think, too, as the world is growing smaller, metaphorically speaking, through communication becoming so easy between countries, that we should try and make our systems uniform. I don't think, there is any question in the mind of any one who has thought the subject over, but what the metric system is the simplest form. If that is the case, then we should all try to adopt that method. I do not think you could persuade the people of the United States to go back to the English system of money. If the question was brought up the first thing that would be said would be as to how cumbersome it was, as a reason for not making the change. I want to give my voice for the adoption of the metric system as far as it is practicable to do so.

Mr. Hibbard: I am very much surprised to hear Professor Carpenter champion that particular phase of the question. I do not believe his argument is a good one, nor do I believe that he is able to-day—possibly (?). he may be—to give the table of linear measure; and I am quite certain he would not attempt the tables of liquid measure and of cubical contents, and all the others, we learned in our arithmetics long years ago. I should be more than surprised if he would give them correctly and remember what they were all about. Now, the metric system would make all that as simple as our currency, and I agree with Mr. Blackmore that we are coming to a time when this country is going to have dealings with all the world, and we are going to be the most important factor in the various transactions of the world, for the time being anyway. The Roman Empire went to pieces after a while, and so did other great nations, and eventually we possibly will, but in our lifetime I am inclined to think that we are going to be "it," and if so, a uniform system of measurements will have to be adopted, or at least it would be very much more convenient to adopt a uniform system, and the metric system must be that system.

The President: Mr. Hibbard, if we are "it "why should we change to theirs, let them change to ours.

Mr. Hibbard: We are "it," but there are at present, more using the metric system. Well—for our own use, then. Put it on the ground of our own convenience.

Mr. Wilkes: What do you think of the last report of the United States on the subject, in which you can find that manufacturers when it came to putting in a bid on the metric system, especially in Russia, were not familiar enough with the metric system to scale the plans, in order to make a price on the work?

TOPIC NO. 3.

"What is the life of metal air ducts, and under what conditions may they be dispensed with."

Mr. Reed: I am not able to say what the life of them is, because all metal ducts that we use are overhead ducts, that is none of them are under ground. Of course, the vertical flues are general enclosed with tile or brick, sometimes metal lath and plaster. We use heavy galvanized iron, No. 24, all the time. I have no trouble from decaying in any way.

The President: How long have they been in, Mr. Reed?

Mr. Reed: We have some that have been in about ten years, but I do not believe there is any signs of decaying; at least, I haven't heard of any.

Mr. Folsom: My experience with metal ducts, as Mr. Reed has already explained, has not been underground, but on columns—that is, with what we call metal ducts, or sheet steel, or galvanized sheet. We find that where that metal is used for other purposes than the passage of air, or where the air is confined, or not moving so as to keep the duct perfectly dry, it rusts a great deal faster than the metal that we used to use several years ago, which was common sheet iron. And to go a little further, where it comes in contact with moisture, as in the manufacturing of tanks, we find it pin-holes very fast, especially where the tank is in contact with something, so that the air cannot circulate on the outside. A case came up in our place a short time ago where there was a galvanized iron (not steel) tank that had been in use for seventeen years, to catch the rain water and whatever might come off the roof. There was also in the same place a lead-lined tank, and the galvanized iron lasted longer by two years than the lead-lined tank. I removed the bottom of the galvanized iron tank and put a steel tank bottom in the first section. It held about fifty barrels, a

storage tank for rain water in the attic of the house. For an air duct or conduit, near the ground, we use galvanized iron as little as possible, for we prefer brick for all ducts where it is possible, or where it is near the ground. Our ducts are all overhead usually. I never use iron under ground, I do not have confidence in it. I use a great deal of galvanized steel, and we always guard against using it close to the ground.

Mr. Mackay: Well, I do not know that I can say much on the question of the life of galvanized iron ducts that would be valuable data. The question as to how they can sometimes be done away with has interested me somewhat. The matter was first brought to my attention at the Master Steam-Fitters' Convention in New York some five or six years ago, when Mr. D. M. Nesbit, who is now one of our members from London, England, presented a paper before that association describing an installation in the City Asylum, Nottingham, England. It covered a very large amount of ground, the exact dimensions I do not know, but it was something in the neighborhood of 500 feet in length, sixty or seventy-five feet in width, and four or five stories in height. I have a photograph of the building here. He utilized the inside walls of the building, the cellar bottom and the ceiling. It was fire-proof construction, and by merely inserting a single brick wall they made a flue that would have cost considerably more to have made the same size in metal; they also had a greater opportunity of cleaning it and seeing that it was clean. It was the janitor's duty to go into that flue and clean it out thoroughly at stated intervals. The flue was lighted by electric lights and it was large enough so that you could walk into it, and the brick walls were kept pure and clean; in some instances they were tiled, and in others they were painted or white-washed.

Another feature that commended itself to me in that particular building, was the location of his heating surfaces; instead of locating his entire surfaces at or near the fan he located it at different points in the building near the points where he wished to distribute it. Last March I had the good fortune to visit England, and I was pleased that I was able to be there during the cold weather, so that I could have an opportunity of looking at some of these installations that I had previously thought well of on paper, having seen them at our own

society meetings where several papers had been presented. And, while I saw a number of their different institutions in England, two of them, the Royal London Ophthalmic Hospital and the Technical School at Leicester, were two that impressed me greatly. In both constructions the walls that formed the halls in the centres of the building formed the flues. They were above the surface of the drainage so that there was no trouble from water. I walked through them with the party who put the work in, Mr. Nesbit, and the engineer of the building. I saw no objectionable features to them in those buildings. The question of space that they took up, it was waste space in the basements there, so that that was not an objection, but it might be objected to in some of our buildings here, but they had sufficient space in those buildings, and I believe in some of our constructions a similar arrangement could be used advantageously. I am using a duct of that sort in a large State institution at the present time, by merely utilizing the brick walls, the fireproof ceiling, and the cement floors, there is no additional brick work at all. They were able to make them larger on account of not wanting to afford the cost of reducing them. In metal flues we make them as small as we can for two reasons: one is space and the other is the cost, and we sometimes get friction that interferes with the efficiency of the circulation, which would be avoided if a larger flue were used. I must say that in these two particular buildings metal flues would not have been an advantage; they do not use an inch of metal in the whole building, except the cast-iron dampers which are placed in the base of the vertical flues that lead from the horizontal duct in the basement.

Mr. Folsom: I will say, it depends on the conditions as to the durability of metal in ducts; in other words, the surroundings make a vast difference. I never try to use galvanized iron ducts in the ground, or where there is more or less moisture. I prefer cement or something else, possibly brick, and I have found that the durability of the metal, speaking of the two metals, galvanized iron or galvanized steel, is about as five to fifteen in favor of iron. That is as near as I can tell it. I know that at times we used to make receptacles for heating water of different kinds of galvanized iron and they would last a long time, say, two to five years; but at present time, if you boil water or

heat water almost to a boiling point, so that the lime is extracted or the sediment is taken out, and let that settle on the present galvanized sheet, the life of it is very short, sometimes six months and sometimes not.

TOPIC NO. 4.

"Why not use small ducts, high velocity and high pressure in ventilating work?"

Professor Carpenter: Mr. President, I suggested that topic mainly for this reason: The present system of distributing air by means of flues through which air flows with small pressure and low velocities, is not applicable to many of the office buildings for the reason that these ducts take up an enormous amount of room that could not be spared. The practice has been suggested of using higher pressure of air and smaller ducts, obtaining thus a practical system for these buildings. Such a system is not entirely new. I think the best passenger steamers of the great lakes, certainly the Great Northern steamers, have a system of high-pressure ventilation, where they use small pipes and high-pressure, distributing the air at very great velocity. They use, for instance, a four- or six-inch pipe, where we would ordinarily put a ten- or twelve-inch pipe. The question is merely advanced as a suggestion for discussion.

The President: About what velocity do they use in those ducts, Professor?

Professor Carpenter: I have no data on that system. I have simply examined it. For an ordinary statement, I think a three- or four-inch pipe supplied all the air, and it comes in under considerable pressure and with great velocity.

The President: Does it whistle as it comes through?

Professor Carpenter: Yes, with the valve in a certain position. It is provided with an adjustable swinging discharge hood and muffler, which breaks up the current and distributes it as desired.

The President: What velocities do you usually use in your school buildings, Mr. Reed?

Mr. Reed: You mean the ducts?

The President: Yes.

Mr. Reed: In the basement ducts we use a velocity of about 900, and in the risers about 600, and about 300 at the opening

where the air enters the room. The question of using smaller air ducts or pipe is something that I expect we will have to do. If we ever heat as well as ventilate office buildings by forced hot-air system, as has been said by Professor Carpenter; either the architects or the owners will not permit us to take up a great deal of space with air flues. Another thing, in office buildings, they seldom want to put in ventilating flues; as much on account of room as anything else. If some system can be worked out—and there is no reason why it cannot be, as in my opinion it is a matter of the proper combination of details—there is no reason why air cannot be conveyed to rooms under high-pressure, using small pipes; and discharging the air under the radiator so as to make the radiators a sort of a direct-indirect.

TOPIC NO. 5.

"What is your experience as to the life of wrought-iron or steel nipples used in connection with cast-iron radiators?"

Mr. Mackay: I have had some experience with the nipples that you mention, and I remember when the first sectional radiators were put on the market the claim was made that the weak point in them would be the joint, and that in a very short time they would go to pieces at that point. That assertion was made by other manufacturers who made a different construction, but my experience has been that the wrought-iron nipple is all right, that there was no real trouble from the original wrought-iron nipples as they were used in cast-iron sectional radiators; the trouble seems to have come later when, either for cheapness or for some other reason, a steel nipple has been used, and sometimes considerably thinner than the original wrought-iron nipple. I have seen nipples of that sort become completely honeycombed and eaten through, in two or three years, while I know of some of the first cast-iron radiators that were put together with wrought-iron nipples to be in use to-day, and apparently in as good condition as when they were first placed. I have some of them in my own home that have been in use on hot water for twelve years, and I do not feel at all suspicious that they will go to pieces on me any more than I do that the pipe in the mains and fittings of the building will go to pieces.

I feel that if the original material which was used, extra heavy wrought-iron nipple, was continued in use that we would have no trouble on that score. I do not know what the experience of others has been, but that has been my experience, that where the trouble existed there was always a cause of it outside of the fact of putting cast-iron sections together with wrought-iron nipples.

The President: Mr. Blackmore, haven't you had some experience with wrought-iron or steel nipples in cast-iron radiators? If you have, we would like to hear from you.

Mr. Blackmore: Mr. President, the steel nipples that were made two or three years ago were liable to corrode, but I think the steel nipples made to-day will stand all right, fully as good as wrought-iron. It is not many years ago since steel boiler tubes would not be accepted in a boiler, but to-day we are getting a steel boiler tube that we are entirely satisfied with, and the same applies to the nipples. There was certain properties in the steel when they first produced it that did not make a good nipple, it did not make a good boiler tube. The boiler tubes we are getting now are satisfactory, and the same will apply to the nipples, and I see no reason why they should not continue to be so. I do not see any reason why a nipple in a cast-iron radiator should not last just as long as a steel tube in a boiler, where the wear is no greater on the one than it is on the other, but in the early days of the steel nipple we certainly had some trouble.

The President: What was that trouble, Mr. Blackmore?

Mr. Blackmore: Well, it was mainly from the pitting.

The President: Where did it occur?

Mr. Blackmore: No particular place. It would rust through in places—in one case it would be at one part of the nipple, and in another case it would be at another part of the nipple.

The President: Would it be at the point of contact, the point of contact of the nipple with the cast-iron?

Mr. Blackmore: Naturally that was the place where it showed, but examination of the nipple showed corroding where it was close to the cast-iron, but not on the inside, the open side of the nipple. I am unable to give any real reason for it other than there are some properties in the steel that they have been able since to remove.

Mr. Mackay: I would say that my experience has been with cases that came under my observation in steam radiators, the decaying has taken place at the bottom third of the nipple, and not always at the bottom, but at each side of the bottom of the nipple.

The President: Inside or outside?

Mr. Mackay: On the inside of the nipple near the bottom, that was in steam radiators where there was possibly a small amount of water laying in the bottom of the radiator.

Professor Carpenter: In the buildings of Cornell University, during the last two years, as reported to me by the Superintendent, Mr. W. C. Dean, there has been an immense amount of trouble from the giving out of wrought-iron or steel nipples in cast-iron radiators, and the workmen have replaced a great many of them. It is believed that nipples which made the trouble were wrought-iron and not steel, for the reason that they were put in before steel was used to any great extent in this work; that is, the radiators failing were ten or twelve years old, aside from that we have no means of telling whether steel or wrought-iron, but at any event, we have had a great deal of trouble from the giving out of nipples of this kind; we have also had similar trouble with both wrought-iron and steel pipe, when used in certain positions. The cause of the failure has not been ascertained, but it seems due to the fact that heated water will attack wrought-iron or steel much more actively than steam or cold water, and that it will not attack cast-iron or materials of that sort. I believe it attacks wrought-iron less actively than it does steel, simply because wrought-iron contains more impurities. Where we have had malleable nipples there has been or seemed to be no difficulty whatever with the radiators, I proposed the question to find out what this general difficulty has been, and if it has been serious enough to warrant any change in the practice of construction.

TOPIC NO. 6.

"What has been your experience with anemometers?"

Professor Carpenter: Mr. President, I am not certain that this discussion will be a profitable one. We all employ the

anemometer a great deal and find it reliable, when we knew what its error is; different individual anemometers have different errors, and these errors are sometimes very great and liable to change, but we find the instrument to have a constant error for a considerable period—of time say, for two or three months. We always have provided means for testing it, at frequent intervals and before we commence to use it; as a result never have obtained any data with it which we did not consider to be reliable. It strikes me that the statement regarding its irregularity made yesterday did not consider all conditions, and that there were other causes; for instance, a possible explanation may have been due to the fact that a current of air flowing through a pipe almost always moves with different rates in different portions of the cross-section, so that if you put an anemometer into it you will find a very great variation in the readings at different parts in the same cross-section; the same irregularity is noted if you hold an anemometer in different positions in front of a register. Such variations in reading is not the fault of the anemometer at all, on the contrary the anemometer is actually showing the true state of affairs.

Mr. Reed: My experience has been very much as Professor Carpenter describes; that is to say, we find different velocities at the various cross-sections of the pipe, quite a difference in the velocity of the air coming through the registers at times, and it seems hard to base too much confidence in the anemometer. I have tried to be very careful in using it, and I had on one occasion in testing the quantity of air delivered into a room made the reading, and a few minutes later I concluded I would check it, and I found a very great difference in the reading. Well, there was an opportunity for reflection, and when I got downstairs, I found out the trouble was that the engineer had shut up one of the openings, and on the second visit we found the anemometer reasonably accurate. However, it seems a very hard matter to make two tests and get two readings exactly alike, they will vary probably over 5 per cent. on one check test and may be 15 per cent. on another.

The President: Any other member who has had any experience with the anemometer? Mr. Folsom, have you used the anemometer?

Mr. Folsom: Mr. President, I have tried to use it; but I

didn't get much satisfaction from it. It may be that the instrument was out of fix, it didn't seem to operate right for us. It may be from lack of experience, and my object in this is to find out from those who have had experience what anemometer would give the best results.

The President: My experience has been that the anemometer with only two hands will work the best and continue to give good results for a long time, much longer than one with quite a number of hands; but every anemometer must be tested. Professor Carpenter, what method of testing do you use at Cornell?

Professor Carpenter: We have recently been using a method of measuring air for calibrating the anemometer, which employs two large gasometers (see vol. vi., page 99 of *Transactions*). From these we determine the volume of air which passes through the pipe, and by comparing that with calculations from the readings of the anemometer, we obtain its error. That method has given very good results. The other method which we have used, and which did not give good results, was that of whirling the anemometer on a fixed arm. The testing of an anemometer is a rather difficult matter. We have frequently tested it by an indirect method which I have described, vol. vi. of the *Transactions*. I am rather inclined to think the latter method may be as satisfactory as any and more easy to apply.

The President: The diameter of this pipe connected to the gasometer, is it the same diameter as the anemometer?

Professor Carpenter: In the case mentioned, it has always been of large diameter with the anemometer fitted in an orifice through which the air was discharged.

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